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Manufacturing Fuel-Switching Capability 1988



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Cover photo: The refinery represents one of the manufacturing plants sampled in this survey.

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Energy Information Administration
Office of Energy Markets and End Use
U.S. Department of Energy
Washington, DC 20585

Contacts

General information concerning the contents of this report may be obtained from Lynda T. Carlson, Director of the Energy End Use Division (202/586-1112). Specific information regarding the contents or preparation of this publication can be obtained from Dwight K. French, Chief of the Transportation and Industrial Branch (202/586-1126).

Detailed technical questions may be referred to the following members of the Energy End Use Division:

Robert K. Adler	Principal Author Estimation and Analysis	202/586-1134
Jean Paananen	Questionnaire Design Analysis	202/586-8952
John L. Preston	Survey Manager Principal Author	202/586-1128
Hattie Ramseur	Related Statistical Publications	202/586-1124
Mark Schipper	Sample Design Estimation and Analysis	202/586-1136

The data from the Manufacturing Energy Consumption Survey (MECS) are included in the Longitudinal Manufacturing Energy Data System (LMEDS) maintained by the Bureau of the Census. The LMEDS file includes yearly data beginning in 1972 for individual establishments that responded to the 1985 and 1988 MECS. In addition to energy data, the file also includes economic data collected by the Annual Survey and Census of Manufactures. A researcher interested in using LMEDS should send a research proposal to EIA for consideration. The EIA, in consultation with the Bureau of the Census, will examine the proposal and review with the researcher how the use of the file may benefit the proposed research. If the use of LMEDS is deemed appropriate, the Bureau of the Census will perform the work on a cost-reimbursable basis.

If you have suggestions to make the data in this report more useful for your needs, or if you wish to submit a research proposal for use of LMEDS, please contact John L. Preston, MECS Manager at:

EI-652, Mail Stop 2G-090
1000 Independence Avenue, SW
Washington, DC 20585

Telephone: 202-586-1128
FAX: 202-586-9753

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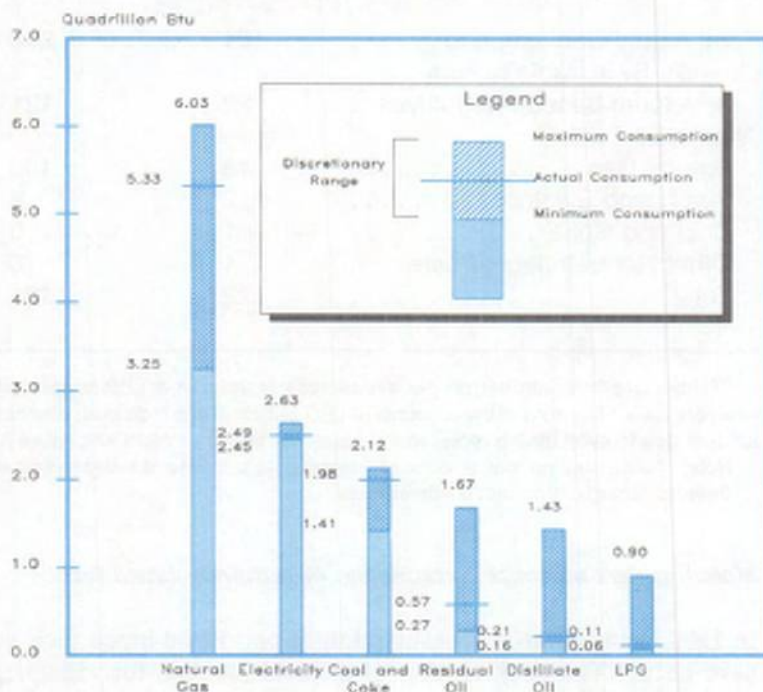
Executive Summary

Historically, about one-third of all energy consumed in the United States has been used by manufacturers. About one-quarter of manufacturing energy is used as feedstocks and raw material inputs that are converted into nonenergy products; the remainder is used for its energy content. During 1988, the most recent year for which data are available, manufacturers consumed 15.5 quadrillion British thermal units (Btu) of energy to produce heat and power and to generate electricity. The manufacturing sector also has widespread capabilities to switch from one fuel to another for either economic or emergency reasons.

There are numerous ways to define fuel switching. For the purposes of the Manufacturing Energy Consumption Survey (MECS), fuel switching is defined as the *capability* to substitute one energy source for another within 30 days with no significant modifications to the fuel-consuming equipment, while keeping production constant.

Fuel-switching capability allows manufacturers substantial flexibility in choosing their mix of energy sources. The consumption of a given energy source can be maximized if all possible switching into that energy source takes place. At the other extreme, consumption can be minimized if all possible switching away from that energy source takes place. The range defined by these two limits represents the **discretionary consumption** of an energy source resulting from fuel-switching capability. Actual consumption lies within that discretionary range. (See Figure E1.) A preference for a given energy source is indicated when its actual consumption approaches its maximum consumption potential. Conversely, a preference for alternative energy sources is indicated when actual consumption approaches its minimum required level. In 1988, coal and coke were used whenever possible, whereas distillate fuel oil and liquefied petroleum gases (LPG) were seldom used as fuels when manufacturers had a choice.

Figure ES1: Manufacturers' Discretionary Consumption Ranges Resulting from Fuel-Switching Capability, 1988



Manufacturers could have reduced domestic oil consumption by only 1 percent by switching fuels

In 1988, manufacturers consumed an average of 3.7 million barrels per day of petroleum-based energy sources. Of that amount, 2.2 million barrels per day were consumed as a feedstock or raw material input. With the exception of some switching between petroleum-based and natural gas-based LPG, switching of feedstocks and raw material inputs is ordinarily not feasible. In the MECS, natural gas- and petroleum-based LPG are treated as a single product class. Another 1.1 million barrels per day were refinery products—still gas and petroleum coke—that were consumed in the normal course of refinery operations. Only the relatively small remainder, 428 thousand barrels per day, or 6 percent of manufacturers' total energy consumption, were petroleum fuels consumed by choice, for which the concept of fuel-switching capability is applicable. A significant part of that fuel use—181 thousand barrels per day—could have been replaced by nonpetroleum fuels (Table ES1). However, it would have been necessary for manufacturers to have exercised *all possible fuel-switching capabilities* out

of petroleum-based fuels. As a result, manufacturers are severely limited in the extent to which they can reduce total U.S. dependence on petroleum-based energy sources. In 1988, total petroleum products supplied for domestic consumption was 17.3 million barrels per day. Manufacturers could have reduced that consumption by only one percent by exercising all fuel-switching capabilities out of petroleum-based fuels to alternative fuels such as natural gas and coal.

Table ES1: Petroleum-Based Fuel Consumption Switchable to Nonpetroleum-Based Alternatives by Manufacturers, 1988
(Thousand Barrels per Day)

Description	Distillate Fuel Oil	Residual Fuel Oil	Liquefied Petroleum Gas	Total Petroleum
Total Actual Consumption	101	248	80	428
Quantity Switchable to Non-petroleum-Based Alternatives .	22	121	^a 38	181
Alternative Fuels:				
Natural Gas	18	100	35	153
Purchased Electricity	2	6	2	9
Coal and Coke	1	9	1	11
Other Nonpetroleum Fuels . . .	1	6	2	10
Total	22	121	40	184

^aThirty-eight thousand barrels per day represents the part of LPG consumption that could have been switched to nonpetroleum alternate fuels. The sum of the amounts of LPG switchable to individual alternative fuels (40 thousand barrels per day) exceeds this amount due to overlapping replacement capability to two or more alternative fuels at some establishments.

Note: Totals may not equal sums of components because of independent rounding.

Source: Energy Information Administration

Manufacturers minimize consumption of petroleum-based fuels

In 1988, manufacturers' consumption of petroleum-based fuels was insignificant compared to what it could have been. The consumption of residual fuel oil, for example, was 248 thousand barrels per day. The consumption of LPG as a fuel and distillate fuel oil was 80 and 101 thousand barrels per day, respectively. Those low levels of consumption existed because manufacturers have the ability to switch fuels. Manufacturers could have increased the consumption of residual oil to 726 thousand barrels per day by switching away from other energy sources such as natural gas. Similarly, they could have increased the consumption of distillate and LPG to 671 and 681 thousand barrels per day, respectively.

Manufacturers have limited opportunities to further reduce the consumption of petroleum-based fuels

Even though manufacturers could have substantially increased their consumption of petroleum-based energy sources by implementing their fuel-switching capabilities, they had limited opportunities to further decrease their consumption of those petroleum-based energy sources. Manufacturers have certain minimum required levels of consumption for most energy sources. Those levels result from the inability of a manufacturer to consume an alternative energy source even in an emergency situation. These minimum requirements can result from the inability to obtain an alternative energy source, limitations of the energy-consuming equipment, process requirements, and environmental restrictions. Of the three petroleum-based fuels, residual fuel oil had the greatest potential to be replaced by nonpetroleum-based energy sources. By instituting all possible nonpetroleum substitutions for residual fuel oil, its consumption could have been reduced from 248 to 127 thousand barrels per day. Similarly, the actual consumption of LPG could have been reduced from 80 to 42 thousand barrels per day, and distillate, from 101 to 79 thousand barrels per day.

Natural gas is the fuel of choice by manufacturers

In 1988, manufacturers consumed 5,141 billion cubic feet (Bcf) of natural gas, and it met 34 percent of their total energy requirements to produce heat and power and to generate electricity. By exercising all possible switching opportunities into natural gas, consumption could have been increased to 5,840 Bcf, and increase of 14 percent. Conversely, by exercising all possible switching opportunities away from natural gas, its consumption could have been reduced to 3,133 Bcf, a decrease of 39 percent. Thus, while there were some opportunities to consume additional natural gas, there were ample opportunities to have reduced its consumption, had manufacturers chosen to do so.

Price differences account for manufacturers' reluctance to consume distillate or LPG in place of natural gas

Had manufacturers chosen to replace natural gas with an alternative energy source, the primary replacements would have been distillate and residual fuel oil and LPG. However, there was very limited economic incentive to replace natural gas with either distillate fuel oil or LPG. In 1988, the average price to manufacturers of natural gas was \$2.52 per million British thermal units (Btu). The average prices of distillate and LPG were \$4.66 and \$5.27 per million Btu, respectively.

Manufacturers chose natural gas over residual oil despite apparently favorable price incentives

Nationally, the average 1988 price of residual oil to manufacturers was \$2.50 per million Btu, nearly equal to the price of natural gas. However, the price of natural gas varied substantially by geographic region, while the price of residual oil remained fairly constant. In the Northeast Census Region, for example, the prices per million Btu were \$2.66 for residual oil and \$3.31 for natural gas. Similar price relationships were found in the Midwest and West Census Regions. Only in the South Census Region was the average price of natural gas less than the average price of residual fuel oil—\$2.17 versus \$2.37 per million Btu. In all regions, however, natural gas was decidedly the preferred energy source. There are several possible reasons why manufacturers did not switch from natural gas to the less expensive residual oil. First, in spite of the fact that the price of residual oil may be less than the price of natural gas, residual may be more expensive to burn because it must be preheated to reduce its viscosity. Second, environmental regulations may limit the quantities of residual that can be consumed. Third, because of flexible natural gas pricing, large consumers often receive a reduction in gas rates without having to switch to the alternative energy source.

Few opportunities exist to replace electricity with an alternative energy source

Electricity was the second most popular energy source consumed by manufacturers in 1988. Total receipts were 728 billion kilowatthours (kWh), which accounted for 16 percent of manufacturers' total input energy requirement. Manufacturers had very little flexibility in choosing how much electricity they could have consumed. By exercising all possible opportunities to replace electricity with an alternative energy source, consumption could have been reduced to 716 billion kWh. Replacing other energy sources with electricity could have increased consumption to 771 billion kWh.

Manufacturers maximize consumption of coke and coal by consuming 90 million short tons as a fuel

Manufacturers' 1988 consumption of coal and coke as an input fuel was 90 million short tons. These energy sources accounted for 13 percent of manufacturers' demand for energy to produce heat and power and to generate electricity. The consumption of coal and coke was close to its maximum, given the levels of production in 1988. Implementing all fuel-switching capabilities from other energy sources to coal and coke could have increased consumption to only 96 million short tons. Conversely, manufacturers could have reduced the consumption of coal and coke to 64 million short tons by exercising all possible opportunities to burn alternative energy sources.

1. Introduction

This report, *Manufacturing Fuel-Switching Capability 1988*, has been prepared by the Energy End Use Division, Office of Energy Markets and End Use, Energy Information Administration (EIA).

The EIA is mandated by Congress to be the agency within the Department of Energy that collects, analyzes, and disseminates impartial, comprehensive data about energy—how much is produced, who uses it, and the purposes for which it is used. To comply with that Congressional mandate, the EIA collects energy data from a wide variety of sources covering a range of topics.¹

The estimates in this report are based on data collected on the 1988 Manufacturing Energy Consumption Survey (MECS), Forms 846 (A through C). The EIA conducts this national sample survey of manufacturing energy consumption on a triennial basis. The MECS is the only comprehensive source of national-level data on energy-related information for the manufacturing industries. The MECS was first conducted in 1986 to collect data for 1985. This report presents information on the fuel-switching capabilities of manufacturers in 1988. This report is the second of a series based on the 1988 MECS. The first report, *Manufacturing Energy Consumption Survey: Consumption of Energy 1988*, presented a comprehensive description of energy consumption by manufacturers.² A future report will present an analysis of changes in energy efficiency. The EIA also conducts energy consumption surveys in the residential, residential transportation, and commercial buildings sectors.

A Guide to the Tables in this Report

Minimum and Maximum Consumption Requirements . . .	Table 1
Switching Capabilities from Specific Energy Sources .	Tables 2-7
Leadtime to Switch	Tables 8-14
Relative Standard Errors	Tables 15-28

The MECS is conducted by the EIA under the authority of the Federal Energy Administration Act of 1974, Public Law 93-275, as amended, and Section 205 of the Department of Energy Organization Act, Public Law 95-91, as amended by Section 3102 of the Omnibus Budget Reconciliation Act of 1986, Public Law 99-509.

The Industry Division of the Bureau of the Census serves as EIA's data collecting and compiling agent for the MECS. All data reported to the Bureau of the Census are confidential under the provisions of Section 9, Title 13, of the U.S. Code.

The EIA gratefully acknowledges the cooperation of the respondents in supplying the information used to produce the estimates in this report.

¹The EIA conducts numerous energy-related surveys. In general, these surveys can be divided into two broad groups. One group of surveys is directed to the suppliers and marketers of specific energy sources. These surveys measure the quantities of specific fuels produced and/or supplied to the market. These types of surveys are called supply surveys. The results of these supply surveys are combined and published in the *Monthly Energy Review*, and other EIA publications. The second group gathers information on the types of energy used by the end users of energy along with the characteristics of those end users that can be associated with energy use. The MECS belongs to the consumption survey group because it collects information directly from the end-users—the manufacturing establishments. There are important differences between the supply and consumption surveys that need to be taken into account in any analysis that uses both data sources. For information on these differences, see Energy Information Administration, *Energy Consumption by End-Use Sector, A Comparison of Measures by Consumption and Supply Surveys*, DOE/EIA-0533 (Washington, DC, April 6, 1990). Appendix C of this report also includes a summary of the differences for the industrial/manufacturing sectors.

²Energy Information Administration, *Manufacturing Energy Consumption Survey: Consumption of Energy 1988*, DOE/EIA-0512(88) (Washington, DC, May 1991).

2. Surveying the Manufacturing Division

The Scope of the 1988 MECS

The manufacturing division³ of the U.S. economy produces final products that consumers purchase, such as automobiles and household furniture, as well as intermediate products such as automobile engines and upholstery fabric that are used by other manufacturers to produce other final or intermediate products. The division is composed of approximately 350,000 establishments.

A manufacturing establishment is generally at a single physical location and is often called a plant, factory, or mill. Manufacturing establishments use mechanical or chemical processes to transform input materials or substances into new products. They ordinarily use power-driven machines and equipment for handling materials. A manufacturing establishment may also assemble components or perform blending operations. Electric utilities, mining operations, agriculture, forestry and fishery operations, and construction are *not* included in the manufacturing division.

The Sample Design

The estimates in this report are based on data collected from a carefully designed sample of approximately 12,000 manufacturing establishments. The major component of the MECS sample is a subset of the sample for the Annual Survey of Manufactures (ASM) conducted by the Bureau of the Census.⁴ The MECS sample was specifically designed to produce high-quality estimates of energy consumption, fuel-switching capability, and related information for industry categories within the manufacturing division.

The industrial categories in the MECS sample conform to the 1987 Standard Industrial Classification (SIC) system developed by the Office of Management and Budget.⁵ That classification system underlies all establishment-based Federal statistics classified by industry. The SIC system is used to promote the comparability of establishment data describing various facets of the U.S. economy.

The SIC system covers the entire field of economic activities and defines industries in accordance with the composition and structure of the economy. The SIC is a hierarchical classification system in which each level contains increasingly homogeneous categories of industrial activities. The levels of classification in the SIC

Expanded Coverage For 1988 MECS Results In Higher Energy Consumption and Fuel- Switching Estimates

The 1988 MECS was designed to produce estimates of energy consumption, fuel-switching capabilities, and other energy-related activities for the *entire* population of manufacturing establishments. It is important to note that the coverage of the 1988 MECS is more comprehensive than the coverage of the 1985 MECS. The 1985 MECS excluded the energy consumption of very small manufacturing establishments. That change in coverage resulted in 1988 energy consumption and fuel-switching estimates that are *two to three percent higher* over all industries than they would have been if the procedures of the 1985 MECS had been similarly followed for the 1988 MECS. The coverage differential is larger for industries dominated by small businesses (such as printing and publishing) than for industries dominated by relatively few large corporations (such as primary aluminum smelting). See Appendix A for additional details.

³The manufacturing division is one of four divisions comprising the industrial sector of the U.S. economy as defined by the Energy Information Administration. The other three divisions in this sector are agriculture, forestry, and fishing; mining; and construction.

⁴Appendix A contains a detailed discussion of the procedures followed to select the MECS sample.

⁵Office of Management and Budget, *Standard Industrial Classification Manual, 1987* (Washington, DC, 1987).

system are: division, major group, industry group, and industry. The manufacturing division contains 20 major groups (SIC 20 through 39).

Manufacturing establishments are classified into industries based on the value of production of specific products. If an establishment produces more than one type of product, it is classified according to the value of production of its primary product. For example, an establishment that is primarily engaged in manufacturing paper from wood pulp, and also manufactures paperboard, is classified in the Paper Mills Industry (SIC 2621). It would not be classified in the Paperboard Mills Industry (SIC 2631).

The population of manufacturing establishments was stratified into 30 industry categories to select the MECS sample. These categories are the 20 major manufacturing groups (two-digit SIC) and the 10 specific manufacturing industries (four-digit SIC) that historically have consumed the largest amounts of energy.⁶ That stratification scheme helps to ensure that the characteristics of an industry category are properly represented by the sample. Stratification also helps to control the sampling error, which is present in all sample surveys.⁷

Defining Fuel-Switching Capability

One way in which energy consumers can adapt to changes in economic conditions, energy supply disruptions, and other constraints on energy use is by having the capability to use more than one fuel to meet their energy needs. For example, a household with a central furnace may also have a wood stove that can assume part or all of the heating load for the house. Hospitals commonly have emergency backup generators that are used to provide electricity during a power outage.

The capability to substitute one energy source for another is especially prevalent in manufacturing. Some manufacturers use combustors that are able to burn two or more different fuels simultaneously, in varying mixtures, to produce the desired heat output. Others have equipment that can burn only one fuel at a time, but that can easily be converted. Still other establishments have multiple combustors that use different fuels to supply heat or power for the same purpose. Ordinarily, not all combustors are required to operate at full capacity to meet heat and power requirements. Thus, these establishments can alter their energy mix by changing the combustors that are in use.

The MECS measures the short-term capability of manufacturing establishments to have used alternative energy sources in place of those actually consumed in 1988 to meet requirements for heat and power, while keeping production constant. Specifically, manufacturers must have operated combustors (boilers, furnaces, ovens, and so on) that had the machinery or equipment in place or available for installation in 1988 so that substitutions actually could have been introduced within 30 days of a decision to switch without extensive equipment modifications. Fuel-switching capability could have resulted from the use of combustors that were already equipped to use alternative fuels, as well as the use of redundant or standby combustors.

As defined in the MECS, *fuel-switching capability does not depend on the relative prices of energy sources*. It depends only on the characteristics of the equipment and practical limitations to fuel-switching such as binding take-or-pay contracts with energy suppliers that were in place, and environmental regulations that limit the amounts of potential replacement energy sources that could have been consumed.⁸

⁶Appendix E contains descriptions of the 30 strata included in the MECS.

⁷See Appendix B for more information on the quality of the estimates.

⁸See Appendix A for a complete description of the concept of fuel-switching capability used in the MECS.

Fuel-switching capability was determined for six major energy sources: electricity receipts,⁹ natural gas, distillate fuel oil, residual fuel oil, liquefied petroleum gases (LPG), and coal and coke combined. For each of these energy sources, switching capability was measured relative to the estimates of the total 1988 inputs of that energy source for heat, power, and the generation of electricity.¹⁰ For each input energy source, respondents were asked to estimate how much of the quantity consumed *could not have been replaced* by any other energy source in 1988, even given a severe curtailment of that energy source.¹¹ The difference between the quantity consumed and the quantity nonswitchable represents the quantity of each energy source that could have been replaced by at least one other energy source. Respondents were then asked to estimate how much of the total replaceable quantity of a given energy source could have been replaced by specific alternative energy sources.

Measures of Fuel-Switching Capability

Manufacturers' capability to replace one energy source by alternative energy sources permits flexibility in choosing how much of a given energy source can be consumed to maintain a given level of production. The tables in this report are designed to answer basic questions about the overall capabilities of manufacturers to have switched energy sources in 1988.

What is the minimum (maximum) consumption of an energy source that could have resulted from fuel switching?

The consumption of a given energy source can be minimized if all possible switching from that energy source takes place (including replacing a petroleum-based energy source by another petroleum-based energy source). In other words, all manufacturers that have the capability to replace the energy source with alternatives must do so to the maximum possible extent. For the MECS, the minimum required consumption of an energy source is estimated from the respondent provided value of "quantity nonswitchable." (See line 2 of section III of the MECS questionnaire in Appendix D). At the other extreme, there is a maximum consumption

An Example of Fuel-Switching Capability

The ABC Manufacturing Plant consumed 2 million cubic feet of natural gas during 1988. Of that amount, 500 thousand cubic feet were consumed in paint-drying ovens, which were not switchable because other energy sources would change the tint of the pigments in the paint, rendering the products unsalable. The remaining natural gas was consumed in a boiler that was run at 100 percent capacity and provided 75 percent of the steam requirement of the plant. That boiler could burn either natural gas or residual fuel oil and the switch between those two energy sources could have taken place within a few hours. Therefore, the respondent would have reported that 1.5 million cubic feet of natural gas could have been replaced by residual fuel oil.

In addition, the ABC Manufacturing Plant operated a coal-fired boiler at an average of 50 percent of its capacity during 1988. That boiler provided the remaining 25 percent of the steam requirement of the plant. There were no environmental or other restrictions to prevent this boiler from running at full capacity. At full capacity, the coal-fired boiler could have provided 50 percent of the steam requirement of the plant, and the natural gas-fired boiler could have been reduced to two-thirds of its capacity. Thus, 500 thousand cubic feet of natural gas (one-third of 1.5 million cubic feet) could have been replaced by coal.

⁹The estimate of electricity receipts represents those quantities of electricity that were produced offsite and available onsite for consumption. The estimate does not include electricity generated onsite nor has it been adjusted to account for any quantities that might have been resold or transferred to another establishment.

¹⁰A comprehensive description of energy consumption in manufacturing needs to reflect two different concepts of energy demand. The MECS' measure of total inputs for heat, power, and electricity generation represents an unduplicated "final use" accounting of energy used for its heat content, and is the appropriate measure on which to base estimates of fuel-switching capability. The other measure of energy consumption is total primary consumption for all purposes. That measure represents the total requirement for energy sources, whether or not they are used for their energy content. See Energy Information Administration, *Manufacturing Energy Consumption Survey: Consumption of Energy 1988*, Appendix A for more details on the measures of consumption.

¹¹See Appendix D for copies of the MECS questionnaires.

potential for each energy source. Maximum consumption potential represents the quantity of a given energy source that would have been required if all possible switching into that energy source had taken place¹². The difference between the minimum consumption requirements and maximum consumption potential represents the discretionary range within which actual consumption lies. The estimates of actual consumption, nonswitchable minimum requirements, and maximum consumption potential are shown in Table 1 of this report. Those estimates are presented for the total United States and each of the four census regions.¹³

One of the more interesting summary statistics that can be developed from the estimates of minimum required consumption, actual consumption, and maximum consumption potential is the **discretionary use rate**. The discretionary use rate is a measure (in percent) of the extent to which manufacturers elected to consume discretionary quantities of a given energy source. If manufacturers had chosen to minimize their consumption of a given energy source by using alternative energy sources whenever possible, the discretionary use rate would be zero percent. At the other extreme, if manufacturers had chosen to maximize the consumption of a given energy source using that energy source whenever possible, the discretionary use rate would be 100 percent. The rate is calculated as:

$$USE = \left(\frac{ACT - MIN}{MAX - MIN} \right) \times 100 ,$$

where *USE* is the discretionary use rate of a given energy source, *ACT* is the actual consumption of that energy source, *MIN* is the minimum required consumption, and *MAX* is the maximum consumption potential. Thus, the discretionary use rate is a measure of how far (in percent) into the discretionary range of consumption manufacturers chose to go, given their fuel-switching capabilities and production levels of 1988.

What are the candidate replacement energy sources? What are their replacement capabilities?

The basic measure of fuel-switching capability is the ability to switch *from* a given energy source to one or more alternative energy sources. The capability to switch from each of the six major energy sources to specific alternative energy sources is presented in Tables 2 through 7. Each of these tables is expressed in the standard physical units of the designated energy source. For example, Table 2 presents information on the capability to switch from electricity to alternative energy sources. All of the values in that table are in millions of kilowatthours (kWh). Therefore, the estimates for specific alternative energy sources reflect the quantity of the designated energy source that *could have been replaced* by the specific alternative. Table 2 shows that electricity receipts by manufacturers were 728,168 million kWh. Of that amount, 11,264 million kWh could have been replaced by one or more alternative energy sources. Natural gas could have replaced 8,372 million kWh, distillate fuel oil could have replaced 3,228 million kWh, and so on. Note that the sum (not shown) of the replacement quantities of alternative energy sources *exceeds* the total switchable quantity of a given energy source. In Table 2, for example, the sum of the alternative types of energy is 20,455 million kWh, while the total switchable quantity of electricity is only 11,264 million kWh. The difference between those two values is attributable to multiple switching capabilities, that is, more than one energy source could have been substituted for electricity. The estimates in Tables 2 through 7 are presented for the 30 industrial categories defined for the MECS, by census region, and by the value of shipments and employment size classes of the manufacturing establishments.

¹²The estimates of maximum consumption potential of a given energy source assume that all ascertained switching into that energy source could have simultaneously taken place. See Appendix A for more details.

¹³See Appendix F for a map of the census regions.

To what extent can petroleum-based energy sources be replaced by nonpetroleum-based energy sources?

It is possible to approximate the quantities of distillate fuel oil, residual fuel oil, or LPG that could have been replaced by nonpetroleum-based energy sources from the data presented in this report. Table 5, for example, shows that the actual consumption of residual fuel oil in 1988 was 90,413 thousand barrels and that 46,767 thousand barrels were switchable to other energy sources. Natural gas could have replaced 36,611 thousand barrels. Electricity could have replaced 2,002 thousand barrels; coal and coke, 3,166 thousand barrels; and "other," 2,354 thousand barrels. The sum of these nonpetroleum-based alternative energy sources is 44,133 thousand barrels. Thus, the consumption of residual fuel oil could have been reduced to 46,280 thousand barrels (90,413 minus 44,133) by utilizing all possible switching capabilities to nonpetroleum-based energy sources. Such estimates are approximations because of possible redundancies in the replacement capabilities of the nonpetroleum-based alternatives. Such redundancies would tend to overestimate the amount of a petroleum-based energy source that could be replaced by nonpetroleum-based energy sources. However, it would be expected that such redundancies would be relatively small and within sampling error (see below).

How quickly can an input energy source be replaced by alternative energy sources?

The MECS also collects data on the minimum lead time required to switch from each of the six input energy sources. These data break down the 30-day allowable switching period into three shorter periods: less than 1 day, 1 day to 1 week, and more than 1 week but within 30 days. In a few cases, where the minimum lead time was not reported, the switchable consumption was assigned to the category "lead time not ascertained." Table 8 presents estimates of the total switchable quantities of the six major input sources (as reported in Tables 2 through 7) that could have been replaced within these time periods. For example, of the total switchable quantity of electricity (11,264 million kWh as reported in Table 2), 6,376 million kWh could have been replaced in less than one day by one or more alternative energy sources. Tables 9 through 14 present similar information for specific alternative energy sources. For example, Table 10 shows that of the 8,372 million kWh of electricity that could have been replaced by natural gas, 5,336 million kWh could have been replaced in less than one day. Tables 9 through 14 also provide the time-to-switch estimates by census region.

How much error is associated with the estimates of fuel-switching capability?

The estimates of fuel-switching capability are based on a national probability sample of manufacturing establishments. While this sample has been scientifically selected to provide reliable estimates, all sample-based surveys are subject to sampling error.¹⁴ Tables 15 through 28 present the estimates of the relative standard errors (RSE) corresponding to the estimates in Tables 1 through 14. A RSE can be used to evaluate how precisely a given sample statistic estimates the corresponding population value. The larger the RSE, the less precise the estimate. For example, the sample estimate of the minimum consumption potential of natural gas for the United States is given as 3,133 billion cubic feet (Bcf) in Table 1. The corresponding RSE from Table 15 is 3 percent. Similarly, the estimate for the minimum consumption of natural gas in the Northeast Census Region is 249 Bcf, and the corresponding RSE is 6 percent. Thus, it may be concluded that the estimate for the Northeast Census Region is relatively less precise than the estimate for the total United States.

Confidence intervals can also be developed from an estimate and its associated RSE. A confidence interval is a range of values that has a known probability of containing the true, but unknown population value with repeated sampling. Prior to forming a confidence interval, the RSE must be converted to a standard error. The standard error for minimum estimate of natural gas consumption in the United States is 3 percent of 3,133 Bcf, or 94 Bcf. The estimated value plus and minus two standard errors includes the true population value for about 95 percent of all samples. The 95 percent confidence interval for the minimum natural gas consumption is 3,313 plus and minus 188, or 2,945 to 3,321 Bcf.

¹⁴See Appendix B for a more detailed discussion of sampling error.

3. Overview of the Findings

In 1988, manufacturers consumed 15.5 quadrillion British thermal units (Btu) of energy to produce heat and power and to generate electricity.¹⁵ Six energy sources provided 69 percent of that energy. The most widely consumed energy source was natural gas, which accounted for 34 percent of total input energy requirements. Electricity provided 16 percent and coal and coke, 13 percent. The major petroleum fuel products combined—residual and distillate fuel oil and liquefied petroleum gases (LPG)—accounted for only 6 percent. The remaining 31 percent consisted of miscellaneous energy sources including by-product fuels produced onsite from nonenergy materials. Manufacturers achieved this mix of energy sources by the everyday choices they made about the fuels they used. Given a different set of circumstances, manufacturers could have chosen to switch fuels, and the mix of energy sources could have been entirely different.

The Capability to Switch from Oil

Numerous recent events—the crisis in heating oil markets, the Persian Gulf War, the 1990 amendments to the Clean Air Act, the 20th anniversary of Earth Day, the development of the National Energy Strategy—have refocused America's attention on energy. Questions are being asked about the quantities of energy consumed by various sectors and how energy conservation measures could help reduce the dependency of those sectors on petroleum-based energy sources in general, and imported crude oil in particular.

The manufacturing sector consumed an average of 3.7 million barrels of petroleum-based energy products in 1988. If manufacturers had exercised *all possible fuel-switching capabilities* from petroleum-based energy sources to nonpetroleum-based alternatives, that level of consumption could have been reduced by only 181 thousand barrels per day, or 5 percent of their total petroleum-based energy products.

Petroleum Products Meet 43 Percent of U.S. Energy Requirements

In 1988, the total petroleum products supplied for domestic use averaged 17.3 million barrels per day (bbl/d).¹⁶ Net imports of crude oil and petroleum products amounted to 6.7 million bbl/d, or 38 percent of the total products supplied. Finished motor gasoline accounted for the largest share of the supplied petroleum products—7.4 million bbl/d or 42 percent of the total. Distillate fuel oil (including diesel fuel) was second, with 3.1 million bbl/d (18 percent), followed by LPG, which accounted for 1.7 million bbl/d (10 percent). Jet fuels accounted for 1.4 million bbl/d (8 percent) and residual fuel oil, 1.4 million bbl/d (8 percent). The remaining 2.3 million bbl/d (14 percent) consisted of miscellaneous petroleum products such as asphalt and road oil, lubricants, naphthas, and so on.

In order to compare the consumption of petroleum products (normally measured in 42-gallon barrels) to other energy sources such as natural gas (normally measured in cubic feet), it is necessary to convert all energy sources to a common base. British thermal units measure heat content and is one such conversion.¹⁷ The total heat content of the petroleum products supplied was 34.2 quadrillion Btu.¹⁸ Gross energy consumption in the United States in 1988 was 80.2 quadrillion Btu. Thus, petroleum products provided 43 percent of total energy needs. Clearly, the United States is an oil-dependent Nation.

¹⁵Energy Information Administration, *Manufacturing Energy Consumption Survey, Consumption of Energy 1988*, Table 3.

¹⁶Energy Information Administration, *Petroleum Supply Annual 1988*, DOE/EIA-0340(88)/1 (Washington, DC, May 1989), Table 3.

¹⁷A British thermal unit is the quantity of heat needed to raise the temperature of 1 pound on water by 1 degree Fahrenheit at or near 39.2 degrees Fahrenheit.

¹⁸Energy Information Administration, *Monthly Energy Review*, DOE/EIA-0035(91/05) (Washington, DC, May 1991), Tables 2.2 through 2.6.

These petroleum products were consumed primarily by the transportation sector, which includes all public and private vehicles that move people and commodities. That sector alone accounted for 21.5 quadrillion Btu, or 63 percent of the total consumption of petroleum products. These products consisted primarily of finished motor gasoline, jet fuel, diesel fuel, and lubricants.

The residential and commercial sector consumed 2.7 quadrillion Btu (8 percent) of petroleum products, and the electric utility sector, 1.6 quadrillion Btu (5 percent). The major energy sources consumed in these sectors were residual and distillate fuel oil. The industrial sector accounted for 8.6 quadrillion Btu or 25 percent. The industrial sector, as defined by EIA, includes manufacturing, construction, mining, agriculture, fishing, and forestry establishments.

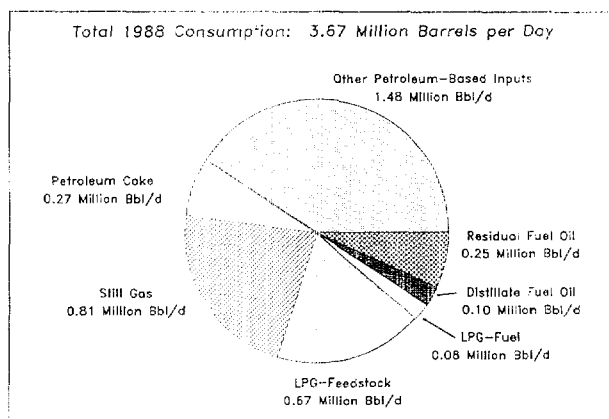
Manufacturers Can Affect Only the Fringes of U.S. Consumption of Petroleum Products Through Fuel Switching

In 1988, the manufacturing sector consumed an average of 3.7 million bbl/d of petroleum products (Figure 1) and accounted for about 20 percent of the total petroleum products supplied for domestic consumption. Of that total consumption, only 181 thousand bbl/d could have been replaced by non-petroleum-based energy sources. These switchable energy sources were distillate and residual fuel oil and LPG consumed as a fuel. The total consumption of these fuels was 428 thousand bbl/d.

The other petroleum products consumed by manufacturers consisted of still gas¹⁹ and petroleum coke²⁰ consumed as fuels, LPG consumed as a feedstock, and other petroleum-based energy sources—principally crude oil—consumed to produce final products²¹. In general, these other petroleum products cannot be replaced by nonpetroleum-based alternatives.²²

Thus, manufacturers are potentially able to reduce the total consumption of petroleum products in the United states by only 1 percent, and even this would require exercising *all possible opportunities* to replace petroleum-based energy sources with nonpetroleum-based alternatives.

Figure 1: Consumption of Petroleum-Based Energy Sources by Manufacturers, 1988



Source: 1988 Manufacturing Energy Consumption Survey, Energy Information Administration.

¹⁹Still gas—also known as refinery gas—is any mixture of gases produced in refineries by distillation, cracking, reforming, and other processes. The principal constituents are methane, ethane, ethylene, normal butane, butylene, propane, propylene, etc.

²⁰Petroleum coke is a residue, the final product of the condensation process in cracking at petroleum refineries.

²¹Petroleum refineries produce numerous final products that are consumed by all sectors of the economy: asphalt, road oil, lubricating oil, petrochemical feedstocks such as naphtha and other oils, solvents, and waxes. These energy products are not recognized or accounted for as energy sources by their consumers and would not be reported as such in an energy consumption survey. Accordingly, the petroleum-based inputs to produce these products are shown as being consumed by petroleum refineries in the manufacturing sector. For more details, see Energy Information Administration, *Manufacturing Energy Consumption Survey, Consumption of Energy 1988*, Appendix A.

²²Small quantities of marketable petroleum coke may be switchable to nonpetroleum-based alternatives. In addition, LPG may be extracted from natural gas or crude oil. For further discussion, see Energy Information Administration, *Estimates of Short-Term Petroleum Fuel Switching Capability*, DOE/EIA-0526 (Washington, DC, May 1989), pp. 16-17.

Manufacturers Minimize Consumption of Petroleum Fuel Products

At 428 thousand bbl/d, petroleum fuel products were the least-consumed energy sources by manufacturers. On an annual basis, that level of consumption is the equivalent of 0.9 quadrillion Btu and represented only 6 percent of manufacturers' total input energy requirement. Moreover, there was little additional flexibility in manufacturers' capability to have substituted alternative energy sources for these petroleum-based fuels. There was, however, substantial capability to have increased their consumption.

Petroleum Fuel Products At A Glance			
	Distillate Oil	Residual Oil	LPG
Actual Consumption*	101	248	80
Percent of Input Energy Demand	1%	4%	1%
Total Switchable Consumption*	25	128	38
Consumption Switchable to			
Nonpetroleum-Based Alternatives*	22	121	38
Minimum Required Consumption*	76	120	42
Maximum Possible Consumption*	671	726	681
Discretionary Use Rate	4%	21%	6%
Average Price per Million Btu	\$4.66	\$2.50	\$5.27

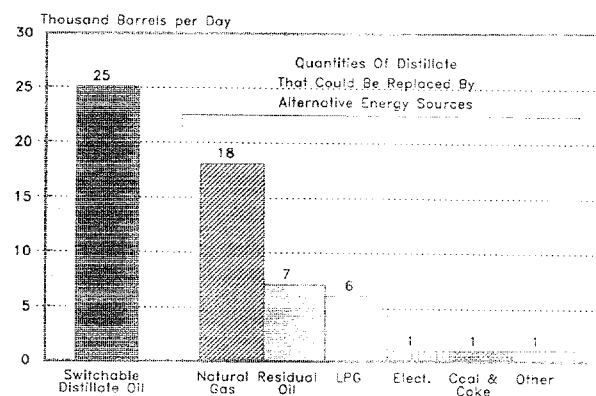
* Thousand Barrels Per Day

Source: Energy Information Administration

Distillate Fuel Oil. In 1988, manufacturers consumed an average of 101 thousand bbl/d of distillate fuel oil, which accounted for 1 percent of total input energy. That consumption could have been increased to 671 thousand bbl/d by exercising all possible switching options from other energy sources to distillate. There was very little opportunity to decrease the consumption of distillate fuel oil, however. By exercising all possible options to replace distillate fuel oil by any alternative energy sources (including other petroleum-based fuels), the consumption could have been reduced to 76 thousand bbl/d. Thus, manufacturers' discretionary use rate (see Chapter 2) of distillate was only 4 percent. That extremely low use rate indicates that manufacturers generally avoided consuming distillate fuel oil whenever possible.

Manufacturers could have reduced the consumption of distillate fuel oil to an average of 79 thousand bbl/d by switching to nonpetroleum-based energy sources only. The principal nonpetroleum-based alternative energy source for distillate fuel oil was natural gas, which could have replaced 18 thousand bbl/d (Figure 2). Switching to natural gas from distillate fuel oil could have been accomplished rather quickly. Of the total switchable quantity of distillate to natural gas, 12 thousand bbl/d or 65 percent could have been switched in less than 1 day (Table 10). An additional 4 thousand bbl/d of distillate fuel oil could have been replaced by electricity, coal and coke, and other miscellaneous nonpetroleum-based energy sources.

Figure 2: Alternative Energy Sources for Distillate Fuel Oil, 1988



Source: Table 4 of this report.

Liquefied Petroleum Gas. Manufacturers' consumption patterns for LPG as a fuel were similar to the patterns for distillate fuel oil. LPG consumption was 80 thousand bbl/d, or 1 percent of manufacturers' total input energy. That consumption could have been reduced to 42 thousand bbl/d by switching to any alternative energy source. The maximum consumption potential was 681 thousand bbl/d. The discretionary use rate for LPG was only 6 percent. As with distillate fuel oil, manufacturers generally consumed no more LPG as an input fuel than was necessary.

The minimum required consumption level of LPG could have been reached by switching to nonpetroleum-based energy sources only. Natural gas, which could have replaced 35 thousand bbl/d of LPG, was the principal nonpetroleum-based alternative energy source (Figure 3). Switching from LPG to natural gas also could have been accomplished quickly. Of the total switchable quantity of LPG to natural gas, 24 thousand bbl/d or 68 percent could have been replaced in less than 1 day. An additional 4 thousand bbl/d of LPG could have been replaced by some combination of electricity, coal and coke, and other miscellaneous nonpetroleum-based energy sources.

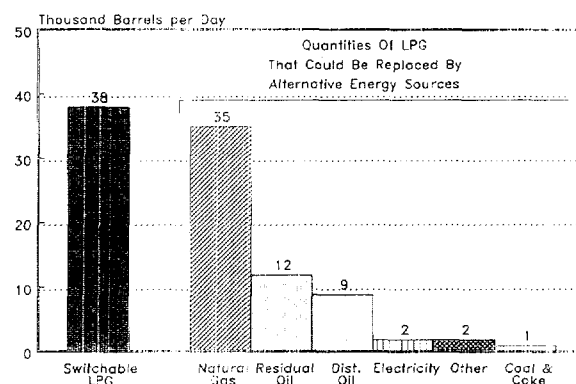
A possible explanation for manufacturers' not replacing distillate fuel oil and LPG by less expensive natural gas is that either distillate fuel oil or LPG was the preferred energy source for a variety of technical or logistical reasons.

Residual Fuel Oil. The consumption and fuel-switching patterns of residual fuel oil are somewhat different from distillate fuel oil and LPG. Manufacturers consumed an average of 248 thousand bbl/d of residual fuel oil in 1988—the highest rate of consumption of the petroleum fuel products. However, that level of consumption accounted for only 4 percent of total input energy. Manufacturers could have reduced their consumption of residual fuel to a minimum level of 120 thousand bbl/d by exercising all possible options to consume other petroleum-based and nonpetroleum based alternative energy sources in place of residual oil. Maximum possible consumption was 726 thousand bbl/d—a level that could have been achieved by exercising all possible options to consume residual oil in place of other energy sources. The discretionary use rate for residual fuel oil was 21 percent. Even though that rate was considerably higher than the use rates for distillate fuel oil and LPG, it was still low enough to indicate a preference for other energy sources over residual fuel oil.

Manufacturers could have reduced the consumption of residual fuel oil to an average of 127 thousand bbl/d by switching to nonpetroleum-based energy sources only. The primary replacement energy source for residual fuel oil is natural gas, which, in 1988, could have replaced 100 thousand bbl/d (Figure 4). Sixty-seven percent of that replacement could have been accomplished in less than 1 day. An additional 21 thousand bbl/d of LPG could have been replaced by electricity, coal and coke, and other miscellaneous nonpetroleum-based energy sources.

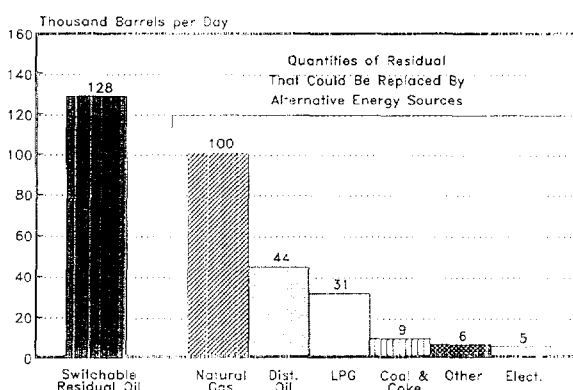
Switching from residual fuel oil to either distillate fuel oil or LPG is not typically economically feasible because the price of residual oil is substantially less than the prices of distillate oil and LPG.

Figure 3: Alternative Energy Sources for Liquefied Petroleum Gases, 1988



Source: Table 7 of this report.

Figure 4: Alternative Energy Sources for Residual Fuel Oil, 1988



Source: Table 5 of this report.

As a result, switching capability from residual oil to distillate or LPG is not as prevalent. Distillate oil could have replaced 16.1 million barrels of residual oil, and only 4.3 million barrels or 26 percent could have been replaced in less than 1 day. LPG could have replaced only 11.2 million barrels of residual oil and 5.0 million barrels or 45 percent could have been replaced within 1 day.

The Capability to Switch from Natural Gas

Natural Gas: The Fuel of Choice by Manufacturers

In 1988, manufacturers met 34 percent of their total input energy requirement by consuming 5,141 billion cubic feet (Bcf) of natural gas (Table 1). Manufacturers had limited additional capability to consume natural gas in 1988. By exercising all possible fuel-switching options from other energy sources to natural gas, and by holding production constant at 1988 levels, consumption could have been increased to no more than 5,840 Bcf, an increase of 14 percent. Manufacturers could have decreased natural gas consumption by 39 percent to 3,133 Bcf and maintained their 1988 level of production by exercising all possible options to consume alternative energy sources in place of natural gas. Thus, manufacturers' discretionary range of natural gas consumption was 2,707 Bcf, and their use rate within that range was 74 percent. In other words, manufacturers chose to consume 74 percent of their discretionary range of natural gas over and above the minimum required consumption. That relatively high use rate is an indication of manufacturers' preference for natural gas over other energy sources.

Natural Gas At A Glance

Actual Consumption*	5,141
Percent of Input Energy Demand	34%
Switchable Consumption*	2,008
Minimum Required Consumption*	3,133
Maximum Possible Consumption*	5,840
Discretionary Use Rate	74%
Average Price per Million Btu	\$2.52

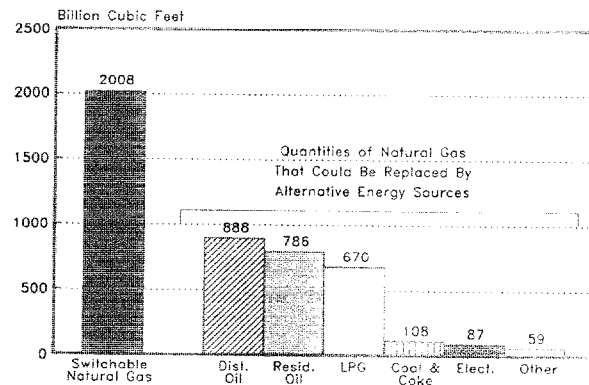
* Billion cubic feet

Source: Energy Information Administration

Petroleum Products Are Primary Alternatives For Natural Gas

The primary replacement energy sources for natural gas are distillate and residual fuel oil and LPG (Figure 5). Individually, none of these energy sources could have decreased the consumption of natural gas to its minimum required level of 3,133 Bcf. Distillate fuel oil could have replaced 888 Bcf. Of that quantity, 353 Bcf or 40 percent could have been replaced in less than 1 day (Table 11). If manufacturers had chosen to consume the maximum amount of distillate fuel oil in place of natural gas, they would have had to increase their distillate consumption from 101 to 532 thousand bbl/d. There was, however, no price incentive to replace natural gas with distillate fuel oil, even though that capability existed in 1988. Nationally, the price of natural gas was \$2.52 per million Btu, while the price of distillate fuel oil was \$4.66 per million Btu.²³ The price of distillate fuel was uniformly higher than the price of natural gas in the four census regions.

Figure 5: Alternative Energy Sources for Natural Gas, 1988



Source: Table 3 of this report.

²³Energy Information Administration, *Manufacturing Energy Consumption Survey, Consumption of Energy 1988*, Table 30.

A similar situation existed for consuming LPG in place of natural gas. LPG could have replaced 670 Bcf of natural gas in 1988, of which 296 Bcf or 44 percent could have been replaced in less than 1 day (Table 14). The maximum replacement of natural gas by LPG would have required manufacturers to have increased their 1988 LPG consumption from 80 thousand bbl/d to 606 thousand bbl/d. The average price of LPG in 1988 was \$5.27 per million Btu. Again, there was no price incentive to replace natural gas with LPG.

Manufacturers Chose Natural Gas Over Residual Fuel Oil Despite Favorable Price Incentives

The decision not to replace natural gas by residual fuel oil is less clear. In 1988, 129.0 million barrels (an average of 353 thousand bbl/d) of residual fuel oil could have replaced 786 Bcf of natural gas—43 percent of that replacement could have been accomplished within 1 day (Table 12). Maximally replacing natural gas by residual fuel oil would have required manufacturers to have increased their consumption of residual from 248 thousand bbl/d to 602 thousand bbl/d. Nationally, the price of residual fuel oil was \$2.50 per million Btu, an estimated value that is not significantly different from the price of natural gas. Thus, nationally, there was little price incentive in favor of one energy source or the other. There were, however, wide geographic differences in the prices of these two energy sources, which add an interesting dimension to the decision not to switch from natural gas to residual fuel oil.

In the Northeast Census Region, the reported price of natural gas was \$3.31 per million Btu, while the price of residual fuel oil was \$2.66, yielding a gas-oil price ratio of 1.24. In the Midwest Census Region, the prices of natural gas and residual fuel oil were \$2.89 and \$2.45, respectively, with a price ratio of 1.18. The West Census Region presented a similar situation—the price of residual fuel oil was \$2.42 per million Btu, and natural gas, \$2.82, with a price ratio of 1.17. Only in the South Census Region were the prices of these two energy sources reversed. Residual fuel oil was \$2.37 per million Btu, and natural gas was \$2.17, yielding a price ratio of 0.92.²⁴ In the South Census Region, there was no price incentive to switch from natural gas to residual fuel oil. In the other three census regions, however, it would appear that the price incentive to switch was quite strong. According to the MECS, however, these three regions consumed 1,109 Bcf of natural gas, of which 451 Bcf could have been replaced by less expensive residual fuel oil in 1988.

The decision to switch energy sources is a complex issue and does not depend on price ratios alone. In the case of natural gas and residual fuel oil, for example, there is no commonly accepted price differential that will trigger a switch from one to the other. Data collected by the American Gas Association for the period 1980 through 1986 indicate that approximately 40 percent of the survey respondents switched from natural gas to residual fuel oil at gas-oil price ratios of 1.05 or less and 60 percent switched at 1.10 or less. The remaining 40 percent switched at ratios as high as 1.25.²⁵ As pointed out by the Electric Power Research Institute (EPRI):

... for industrials, fuel is rarely a large share of their variable costs... As a result, some industrials ... place a higher value on reliability of supplies, contractual relationships and operational considerations. [Thus,] ... a higher price differential may be required for many industrials before they will actually switch to alternative fuels.²⁶

In addition, manufacturers frequently benefit from flexible pricing of natural gas. According to the EPRI:

²⁴The primary reason for the geographic variability in the prices of residual fuel oil and natural gas is the cost of transporting these energy sources to consumers. In the case of natural gas, prices reflect the cost of transportation from the wellhead to the consumer. During 1988, Texas and Louisiana produced 11.5 trillion cubic feet of natural gas, 64 percent of the Nation's total marketable production. The higher costs in areas outside of the south reflect the costs of pipeline transportation. See Energy Information Administration, *Natural Gas Annual 1988*, DOE/EIA-0131(88)/1 (Washington, DC, October 25, 1989). The prices of residual fuel oil are also influenced by the cost of transportation. In general, the prices of fuel oils vary little in locations reachable by water transportation. However, transportation by truck or rail is more expensive than water transportation, and where these transportation modes are used, delivered oil prices are considerably higher. See Electric Power Research Institute, *Fuel Switching and Gas Market Risks, Volume 1*, EPRI P-6822 (Palo Alto, CA, July 1990), p. 2-19.

²⁵Cited in Electric Power Research Institute, *Fuel Switching and Gas Market Risks, Volume 1*, p. 2-19.

²⁶Electric Power Research Institute, *Fuel Switching and Gas Market Risks, Volume 1*, p. 4-13.

As a result of the incremental pricing provisions in the early 1980s, many [natural gas local distribution companies] adopted flexible rates for industrial customers. Those flexible rates for some have become such a normal practice that an industrial firm will often receive a reduction in gas rates without actually having to switch to the alternative fuel....²⁷

Therefore, ratios based on the *average* prices of natural gas and another energy source may not accurately reflect the flexible pricing available to an individual consumer.

At least two other considerations enter into the decision to switch from natural gas to residual fuel oil. First, even though the price of residual oil is less than the price of natural gas in most areas of the country, consuming residual oil may be more expensive than consuming natural gas. One characteristic of fuel oils is viscosity—the extent to which a liquid resists flowing. Residual fuel oils are high viscosity oils and must be preheated for satisfactory use. Such preheating, of course, increases the cost of consuming these oils. Second, the sulphur content of residual fuel oils may limit its use due to environmental restrictions.

Coal and Electricity as Replacements for Natural Gas

Manufacturers could have replaced small quantities of natural gas with coal and coke and electricity in 1988. Coal and coke could have replaced 108 Bcf and electricity, 87 Bcf. The natural gas-coal price ratio was 1.47. In view of that favorable ratio, it is possible that manufacturers did not switch from natural gas to coal for reasons similar to those underlying their reluctance to switch from natural gas to residual fuel oil. The natural gas-electricity price ratio, on the other hand, was 0.19, indicating that manufacturers would be reluctant to switch to electricity except in emergency situations.

The Capability to Switch from Electricity and Coal and Coke

Minimal Switching Capability Exists for Electricity

Electricity was the second most popular energy source consumed by manufacturers in 1988. Total receipts were 728.2 billion kilowatthours (kWh), which accounted for 16 percent of manufacturers' total input energy requirement.

As might be expected, the switching potential for electricity is quite limited because most equipment is not designed to consume either electricity or a combustible energy source. Most of the capability to replace electricity by combustible energy sources is in the form of redundant combustors that can be used in place of electricity-powered equivalents. Of the total receipts of electricity, only 11.3 billion kWh could have been replaced by alternative energy sources.

Electricity At A Glance

Actual Consumption*	728.2
Percent of Input Energy Demand	16%
Switchable Consumption*	11.3
Minimum Required Consumption*	716.9
Maximum Possible Consumption*	771.4
Discretionary Use Rate	21%
Average Price per Million Btu	\$13.44

* Billion kilowatthours

Source: Energy Information Administration

In 1988, the maximum consumption potential for electricity was 771.4 billion kWh, and the minimum required consumption was 716.9 billion kWh. The discretionary range for electricity receipts was, therefore, 54.5 billion kWh and the use rate within that range was 21 percent. The low use rate indicates a preference for other energy sources rather than electricity when such options are available. The dominant single replacement energy source for electricity was natural gas, which could have replaced 8.4 billion kWh (Figure 6). In addition, residual fuel oil could have replaced 4.6 billion kWh; distillate fuel oil, 3.2 billion kWh; or LPG, 2.4 billion kWh. Finally, coal and coke could have replaced 1.2 billion kWh of electricity.

²⁷Electric Power Research Institute, *Fuel Switching and Gas Market Risks, Volume 1*, p. 4-13.

Any one of these alternative energy sources is substantially less expensive than electricity. The electricity-natural gas price ratio, for example, was 5.33 in 1988. The question is, Why did manufacturers not switch to one or more of those less expensive energy sources? First, the quantities of electricity that could have been saved by switching to an alternative fuel were quite small. For a single manufacturing establishment, the savings would be minimal. Second, for certain applications, electricity may have been the preferred energy source, in spite of its higher price.

Coal and Coke Ranks Highest in Discretionary Use

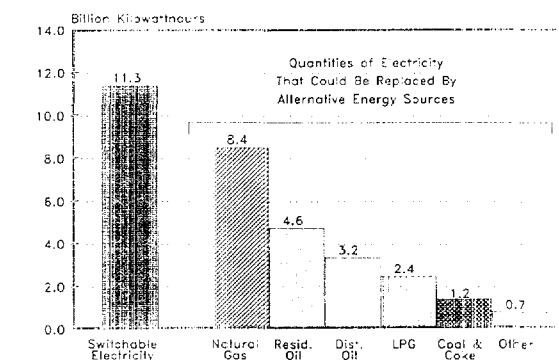
The 1988 consumption of coal and coke by manufacturers was 90.0 million short tons (2.0 quadrillion Btu), and accounted for 13 percent of manufacturers' demand for input energy.

Manufacturers were quite limited in their ability to have consumed additional coal and coke during 1988. They could have increased consumption to only 96.2 million short tons—an increase of 7 percent—by implementing all possible switching opportunities from other energy sources to coal and coke. On the other hand, the minimum required consumption of coal and coke was 64.2 million short tons. Thus, the discretionary range for coal and coke was 32.0 million short tons, and manufacturers' use rate within that range was 80 percent. A use rate of that level indicates manufacturers' strong preference for coal and coke over other energy sources where possible.

The primary replacement energy sources for coal and coke were natural gas and residual and distillate fuel oil. Natural gas could have replaced 16.8 million short tons of coal and coke, of which 8.7 million short tons (52 percent) of that replacement could have been accomplished in less than 1 day (Table 10). Residual fuel oil could have replaced 10.9 million short tons, of which 4.5 million short tons (41 percent) could have been switched in less than 1 day (Table 12). Distillate fuel oil could have replaced 7.8 million short tons. Only 2.7 thousand short tons (35 percent) could have been switched in less than 1 day (Table 11).

There was no price incentive to consume these alternative energy sources in place of coal and coke because the prices of the alternative energy sources were substantially higher than coal. For example, the price of coal was \$1.72 per million Btu, while the price of natural gas—the nearest competitor in terms of price—was \$2.52, resulting in a coal-natural gas price ratio of 0.68.

Figure 6: Alternative Energy Sources for Electricity, 1988



Source: Table 2 of this report.

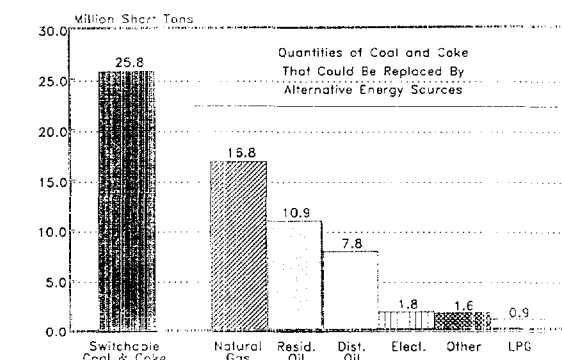
Coal and Coke At A Glance

Actual Consumption*	90.0
Percent of Input Energy Demand	13%
Switchable Consumption*	25.8
Minimum Required Consumption*	64.2
Maximum Possible Consumption*	96.2
Discretionary Use Rate	80%
Average Price per Million Btu	\$1.72

* Million short tons

Source: Energy Information Administration

Figure 7: Alternative Energy Sources for Coal and Coke, 1988



Source: Table 6 of this report.

Detailed Statistics Tables

Table 1. Nonswitchable Minimum Requirements and Maximum Consumption Potential by Census Region, 1988
(Physical Units)

Type of Energy	Actual Consumption	Minimum Consumption ^a	Maximum Consumption ^b
Total United States			
Electricity Receipts ^c (million kilowatthours)	728,168	716,905	771,426
Natural Gas (billion cubic feet)	5,141	3,133	5,840
Distillate Fuel Oil (thousand barrels)	36,766	27,712	244,855
Residual Fuel Oil (thousand barrels)	90,413	43,647	265,080
Coal and Coke (thousand short tons)	89,968	64,179	96,225
LPG (million gallons)	1,226	646	10,441
Northeast Census Region			
Electricity Receipts ^c (million kilowatthours)	99,264	97,971	105,677
Natural Gas (billion cubic feet)	490	249	581
Distillate Fuel Oil (thousand barrels)	11,906	8,966	40,022
Residual Fuel Oil (thousand barrels)	35,685	21,717	59,836
Coal and Coke (thousand short tons)	8,471	6,451	8,841
LPG (million gallons)	W	123	1,139
Midwest Census Region			
Electricity Receipts ^c (million kilowatthours)	211,658	208,077	220,591
Natural Gas (billion cubic feet)	1,389	803	1,634
Distillate Fuel Oil (thousand barrels)	7,163	5,382	67,244
Residual Fuel Oil (thousand barrels)	15,924	4,701	62,039
Coal and Coke (thousand short tons)	44,804	35,705	47,323
LPG (million gallons)	W	161	3,139
South Census Region			
Electricity Receipts ^c (million kilowatthours)	296,328	291,514	317,650
Natural Gas (billion cubic feet)	2,724	1,825	2,970
Distillate Fuel Oil (thousand barrels)	12,408	9,234	99,255
Residual Fuel Oil (thousand barrels)	28,454	14,059	108,018
Coal and Coke (thousand short tons)	W	19,798	34,180
LPG (million gallons)	291	197	4,481
West Census Region			
Electricity Receipts ^c (million kilowatthours)	120,918	119,344	127,508
Natural Gas (billion cubic feet)	538	256	655
Distillate Fuel Oil (thousand barrels)	5,289	4,130	38,334
Residual Fuel Oil (thousand barrels)	10,350	3,170	35,188
Coal and Coke (thousand short tons)	W	2,225	5,881
LPG (million gallons)	432	166	1,682

^a Minimum consumption represents actual 1988 consumption decreased by the quantity of the designated type of energy that would no longer have been required if all ascertained switching from that type of energy had occurred. The minimum value includes the quantity of 1988 consumption for which switching capability was not ascertained.

^b Maximum consumption represents actual 1988 consumption increased by the quantity of the designated type of energy that would have been required if all ascertained switching into that type of energy had occurred. This value assumes that all indicated substitutions were possible simultaneously and the substitutable amount consists of the sum of all possible switches to the designated type of energy. The estimate assumes that 1988 output remained constant.

^c "Electricity Receipts" represents those quantities of electricity generated off the manufacturing establishment site and available at the site for consumption. It includes those quantities for which payment was made, quantities transferred in, quantities purchased and paid for by a central purchasing entity, and quantities for which payment was made in kind. It does not include electricity generated onsite. "Electricity Receipts" has not been adjusted to account for any quantities that might have been resold or transferred out. The estimates include those quantities that were ascertained switchable or not switchable, plus an additional quantity for which the switching status was not ascertained.

W=Withheld to avoid disclosing data for individual establishments. Data are included in higher level totals.

Source: Energy Information Administration, Office of Energy Markets and End Use, Energy End Use Division, Form EIA-846, "1988 Manufacturing Energy Consumption Survey."

Table 2. Capability to Switch from Electricity to Alternative Energy Sources, 1988
(Million Kilowatthours)

Selected Characteristics		Electricity Receipts			Alternative Types of Energy ^a					
		Total Receipts ^b	Switchable	Not Switchable	Natural Gas	Distillate Fuel Oil	Residual Fuel Oil	Coal and Coke	LPG	Other ^c
SIC Code^d	Industry Groups and Industry									
20	Food and Kindred Products	51,690	1,286	47,737	634	682	267	69	Q	42
21	Tobacco Products	1,454	W	W	0	0	0	W	0	0
22	Textile Mill Products	29,684	99	28,150	Q	50	0	W	0	0
23	Apparel and Other Textile Products	6,664	Q	5,923	Q	0	0	0	Q	0
24	Lumber and Wood Products	19,953	Q	18,940	Q	Q	Q	0	0	Q
25	Furniture and Fixtures	5,687	100	5,351	Q	0	Q	56	38	0
26	Paper and Allied Products	61,015	1,251	58,448	940	198	412	387	0	89
2621	Paper Mills	31,184	638	30,319	487	W	W	W	0	W
2631	Paperboard Mills	13,486	377	13,038	308	37	237	167	0	W
27	Printing and Publishing	17,066	Q	15,182	Q	Q	0	Q	0	0
28	Chemicals and Allied Products	129,927	1,485	127,351	1,028	368	303	332	Q	43
2819	Industrial Inorganic Chemicals, nec	27,676	W	27,473	W	0	W	0	0	0
2821	Plastics Materials and Resins	13,259	80	13,003	W	W	W	W	W	0
2869	Industrial Organic Chemicals, nec	19,452	644	18,755	471	201	98	91	0	31
2873	Nitrogenous Fertilizers	2,958	61	2,761	W	W	0	W	0	0
29	Petroleum and Coal Products	34,172	1,943	31,320	1,659	602	702	102	1,035	302
2911	Petroleum Refining	32,243	1,867	29,582	1,614	548	684	W	W	279
30	Rubber and Misc. Plastics Products	31,305	52	29,207	37	24	13	0	26	Q
31	Leather and Leather Products	1,390	52	1,150	Q	W	*	0	Q	Q
32	Stone, Clay and Glass Products	34,017	346	32,231	235	220	72	54	130	73
3241	Cement, Hydraulic	9,861	W	9,673	W	W	0	0	W	0
33	Primary Metal Industries	150,834	2,691	145,189	2,627	98	2,421	Q	W	*
3312	Blast Furnaces and Steel Mills	42,328	2,508	38,846	2,504	W	2,421	0	W	0
3334	Primary Aluminum	65,973	0	65,973	0	0	0	0	0	0
34	Fabricated Metal Products	31,051	356	27,928	Q	129	Q	0	Q	*
35	Industrial Machinery and Equipment	33,894	238	31,013	104	122	Q	Q	Q	0
36	Electronic and Other Electric Equipment	31,878	420	29,251	359	381	Q	Q	Q	W
37	Transportation Equipment	37,965	168	36,227	32	130	W	0	2	W
38	Instruments and Related Products	14,339	328	13,179	Q	Q	161	W	Q	0
39	Misc. Manufacturing Industries	4,183	Q	W	Q	Q	Q	Q	Q	0
	Total	728,168	11,264	688,928	8,372	3,228	4,619	1,198	2,355	683
Census Region										
	Northeast	99,264	1,293	92,552	765	349	763	87	600	29
	Midwest	211,658	3,582	199,918	2,868	941	1,820	318	583	115
	South	296,328	4,814	282,487	3,703	1,213	1,446	701	636	378
	West	120,918	1,575	113,971	1,037	724	590	92	536	160
	Total	728,168	11,264	688,928	8,372	3,228	4,619	1,198	2,355	683
Value of Shipments^e (million dollars)										
	Under 20	125,210	1,107	113,079	654	447	282	207	378	Q
	20-49	112,267	1,447	104,879	967	478	157	Q	208	126
	50-99	90,820	648	85,623	218	400	113	40	49	0
	100-249	131,225	1,279	126,554	861	386	196	143	187	24
	250-499	134,208	1,822	130,978	1,460	390	950	439	234	100
	500 and Over	134,438	4,961	127,816	4,212	1,127	2,920	327	1,299	303
	Total	728,168	11,264	688,928	8,372	3,228	4,619	1,198	2,355	683
Employment Size^e										
	Under 50	53,105	474	48,046	296	333	139	140	142	Q
	50-99	46,336	610	42,165	349	171	Q	14	87	Q
	100-249	126,161	1,852	116,684	1,103	637	221	136	431	43
	250-499	124,309	1,287	118,818	989	573	392	111	397	39
	500-999	165,974	2,164	159,222	1,673	306	656	167	201	223
	1,000 and Over	212,283	4,877	203,993	3,963	1,208	3,066	629	1,097	121
	Total	728,168	11,264	688,928	8,372	3,228	4,619	1,198	2,355	683

^a "Alternative types of energy" consist of those that could have been substituted for electricity receipts during 1988. The quantities are expressed in million kilowatthours and, therefore, represent the quantity of electricity that could have been displaced by the given alternative type of energy.

^b "Total Receipts" represents those quantities of electricity generated off the manufacturing establishment site and available at the site for consumption. It includes those quantities for which payment was made, quantities transferred in, quantities purchased and paid for by a central purchasing entity, and quantities for which payment was made in kind. It does not include electricity generated onsite. "Electricity Receipts" has not been adjusted to account for any quantities that might have been resold or transferred out. The estimates include those quantities that were ascertained switchable or not switchable, plus an additional quantity for which the switching status was not ascertained.

^c "Other" includes all other types of energy not already identified that respondents indicated could have been consumed in place of electricity.

^d See Appendices A and E for descriptions of the Standard Industrial Classification system.

^e Value of Shipments and Employment Size were supplied by the Bureau of the Census. See Appendix A.

*=Estimate less than 0.5 rounded to zero.

W=Withheld to avoid disclosing data for individual establishments. Data are included in higher level totals.

Q=Withheld because Relative Standard Error is greater than 50 percent. Data are included in higher level totals.

Note: Totals may not equal sum of components because of independent rounding.

Source: Energy Information Administration, Office of Energy Markets and End Use, Energy End Use Division, Form EIA-846, "1988 Manufacturing Energy Consumption Survey."

Table 3. Capability to Switch from Natural Gas to Alternative Energy Sources, 1988
(Billion Cubic Feet)

Selected Characteristics		Natural Gas			Alternative Types of Energy ^a					
		Total Consumed ^b	Switchable	Not Switchable	Electricity Receipts ^c	Distillate Fuel Oil	Residual Fuel Oil	Coal and Coke	LPG	Other ^d
SIC Code^e	Industry Groups and Industry									
20	Food and Kindred Products	473	266	187	9	143	122	9	67	2
21	Tobacco Products	2	2	1	0	1	1	*	*	0
22	Textile Mill Products	90	66	20	1	25	36	3	22	1
23	Apparel and Other Textile Products	21	5	14	Q	2	1	*	2	0
24	Lumber and Wood Products	34	9	22	1	2	2	*	5	1
25	Furniture and Fixtures	22	6	14	*	2	1	*	4	*
26	Paper and Allied Products	415	237	172	12	90	151	20	12	3
2621	Paper Mills	173	86	85	6	36	48	10	4	*
2631	Paperboard Mills	155	103	52	4	32	77	9	2	2
27	Printing and Publishing	47	16	25	2	7	5	*	9	*
28	Chemicals and Allied Products	1,465	340	1,107	19	165	144	17	83	21
2819	Industrial Inorganic Chemicals, nec	W	47	W	7	37	14	5	8	*
2821	Plastics Materials and Resins	W	22	W	*	8	8	W	7	0
2869	Industrial Organic Chemicals, nec	587	113	474	7	40	40	6	36	15
2873	Nitrogenous Fertilizers	168	6	162	0	6	W	0	*	0
29	Petroleum and Coal Products	702	278	420	12	111	93	2	186	18
2911	Petroleum Refining	666	258	406	12	90	86	1	182	17
30	Rubber and Misc. Plastics Products	107	60	40	2	38	30	2	7	1
31	Leather and Leather Products	5	2	1	*	1	2	*	*	*
32	Stone, Clay and Glass Products	451	247	187	4	126	41	25	107	3
3241	Cement, Hydraulic	29	24	5	Q	4	6	21	1	1
33	Primary Metal Industries	720	264	439	9	81	103	20	76	W
3312	Blast Furnaces and Steel Mills	425	154	269	W	30	93	19	17	W
3334	Primary Aluminum	19	11	8	0	6	2	0	7	0
34	Fabricated Metal Products	197	60	120	4	24	11	2	31	1
35	Industrial Machinery and Equipment	123	38	74	5	18	9	2	18	W
36	Electronic and Other Electric Equipment	82	38	39	2	20	7	1	15	*
37	Transportation Equipment	134	53	73	2	19	19	4	21	*
38	Instruments and Related Products	31	16	12	Q	11	7	0	3	*
39	Misc. Manufacturing Industries	19	6	10	*	4	2	*	2	*
	Total	5,141	2,008	2,978	87	888	786	108	670	59
Census Region										
	Northeast	490	241	224	8	111	117	6	60	4
	Midwest	1,389	586	748	21	258	221	46	192	11
	South	2,724	899	1,770	45	380	336	46	327	42
	West	538	282	236	13	138	113	11	91	2
	Total	5,141	2,008	2,978	87	888	786	108	670	59
Value of Shipments^f (million dollars)										
	Under 20	645	206	375	16	103	58	20	78	4
	20-49	652	281	333	10	155	88	14	93	5
	50-99	605	325	258	10	175	117	12	100	4
	100-249	886	385	488	12	203	150	21	99	8
	250-499	631	295	332	15	88	154	15	77	7
	500 and Over	1,722	516	1,193	24	163	220	28	223	31
	Total	5,141	2,008	2,978	87	888	786	108	670	59
Employment Size^g										
	Under 50	281	84	167	8	55	24	3	31	3
	50-99	332	120	189	4	67	37	7	39	3
	100-249	868	349	479	12	184	119	28	100	10
	250-499	908	405	478	14	173	158	19	147	5
	500-999	1,071	468	586	21	215	176	14	170	16
	1,000 and Over	1,681	581	1,079	28	194	273	37	182	22
	Total	5,141	2,008	2,978	87	888	786	108	670	59

^a "Alternative types of energy" consist of those that could have been substituted for natural gas during 1988. The quantities are expressed in billion cubic feet and, therefore, represent the quantity of natural gas that could have been displaced by the given alternative type of energy.

^b The estimates of total consumption include those quantities that were ascertained switchable or not switchable, plus an additional quantity for which the switching status was not ascertained.

^c "Electricity Receipts" represents those quantities of electricity generated off the manufacturing establishment site and available at the site for consumption. It includes those quantities for which payment was made, quantities transferred in, quantities purchased and paid for by a central purchasing entity, and quantities for which payment was made in kind. It does not include electricity generated onsite. "Electricity Receipts" has not been adjusted to account for any quantities that might have been resold or transferred out. The estimates include those quantities that were ascertained switchable or not switchable, plus an additional quantity for which the switching status was not ascertained.

^d "Other" includes all other types of energy not already identified that respondents indicated could have been consumed in place of natural gas.

^e See Appendices A and E for descriptions of the Standard Industrial Classification system.

^f Value of Shipments and Employment Size were supplied by the Bureau of the Census. See Appendix A.

*=Estimate less than 0.5 rounded to zero.

W=Withheld to avoid disclosing data for individual establishments. Data are included in higher level totals.

Q=Withheld because Relative Standard Error is greater than 50 percent. Data are included in higher level totals.

Note: Totals may not equal sum of components because of independent rounding.

Source: Energy Information Administration, Office of Energy Markets and End Use, Energy End Use Division, Form EIA-846, "1988 Manufacturing Energy Consumption Survey."

Table 4. Capability to Switch from Distillate Fuel Oil to Alternative Energy Sources, 1988
(Thousand Barrels)

Selected Characteristics		Distillate Fuel Oil			Alternative Types of Energy ^a					
		Total Consumed ^b	Switchable	Not Switchable	Electricity Receipts ^c	Natural Gas	Residual Fuel Oil	Coal and Coke	LPG	Other ^d
SIC Code^e	Industry Groups and Industry									
20	Food and Kindred Products	W	1,211	2,955	Q	1,027	138	Q	243	0
21	Tobacco Products	81	30	49	0	30	*	Q	1	0
22	Textile and Mill Products	1,144	539	422	Q	530	123	16	67	10
23	Apparel and Other Textile Products	397	Q	191	Q	Q	Q	Q	Q	0
24	Lumber and Wood Products	3,835	345	3,262	0	Q	Q	Q	Q	15
25	Furniture and Fixtures	591	Q	431	*	39	Q	Q	Q	Q
26	Paper and Allied Products	2,139	428	1,620	63	260	90	67	76	W
2621	Paper Mills	932	234	680	W	101	38	38	56	W
2631	Paperboard Mills	458	52	388	8	37	11	W	6	0
27	Printing and Publishing	384	124	153	Q	97	12	0	Q	Q
28	Chemicals and Allied Products	2,654	1,101	1,362	10	899	276	36	96	10
2819	Industrial Inorganic Chemicals, nec	W	65	243	0	56	6	W	1	0
2821	Plastics Materials and Resins	248	138	93	W	133	10	0	3	W
2869	Industrial Organic Chemicals, nec	424	126	266	8	123	45	W	3	W
2873	Nitrogenous Fertilizers	24	10	11	0	W	*	0	0	0
29	Petroleum and Coal Products	4,359	1,547	2,615	68	630	1,075	71	917	167
2911	Petroleum Refining	1,138	521	613	W	271	213	12	410	136
30	Rubber and Misc. Plastics Products	785	320	430	Q	229	107	Q	Q	*
31	Leather and Leather Products	169	Q	65	Q	Q	0	0	Q	*
32	Stone, Clay and Glass Products	6,013	1,044	4,309	Q	860	176	160	201	*
3241	Cement, Hydraulic	892	153	682	0	108	27	W	9	*
33	Primary Metal Industries	2,547	587	1,768	12	466	Q	*	Q	36
3312	Blast Furnaces and Steel Mills	1,045	51	979	*	50	0	0	2	W
3334	Primary Aluminum	74	13	60	W	13	0	0	W	0
34	Fabricated Metal Products	1,202	315	744	Q	292	82	Q	95	Q
35	Industrial Machinery and Equipment	1,476	374	934	29	314	70	Q	38	*
36	Electronic and Other Electric Equipment	917	410	425	Q	388	11	4	14	Q
37	Transportation Equipment	W	W	1,580	23	167	65	12	Q	W
38	Instruments and Related Products	368	133	130	*	132	Q	0	Q	W
39	Misc. Manufacturing Industries	275	73	179	Q	39	54	Q	Q	0
	Total	36,766	9,053	23,624	540	6,475	2,397	460	2,256	522
Census Region										
	Northeast	11,906	2,940	7,745	172	2,256	744	99	453	36
	Midwest	7,163	1,780	4,769	141	928	Q	111	Q	40
	South	12,408	3,174	7,484	167	2,490	720	151	656	248
	West	5,289	1,159	3,626	Q	801	202	100	388	147
	Total	36,766	9,053	23,624	540	6,475	2,397	460	2,256	522
Value of Shipments^f (million dollars)										
	Under 20	16,147	2,917	11,362	287	1,647	1,188	165	1,158	Q
	20-49	6,625	2,416	3,443	119	1,901	386	71	307	Q
	50-99	4,405	1,171	2,355	11	1,008	205	115	121	73
	100-249	2,874	732	1,945	48	486	283	37	144	34
	250-499	2,863	827	1,832	40	639	178	59	237	133
	500 and Over	3,852	991	2,686	34	794	158	12	286	37
	Total	36,766	9,053	23,624	540	6,475	2,397	460	2,256	522
Employment Size^g										
	Under 50	10,868	1,879	7,796	169	1,054	1,046	119	792	1
	50-99	4,117	1,070	2,630	Q	718	157	Q	317	117
	100-249	7,025	1,873	4,182	153	1,414	444	144	450	79
	250-499	4,898	1,679	2,723	Q	1,285	273	Q	162	248
	500-999	4,176	1,369	2,127	62	986	278	15	346	41
	1,000 and Over	5,681	1,183	4,164	50	1,019	199	93	187	36
	Total	36,766	9,053	23,624	540	6,475	2,397	460	2,256	522

^a "Alternative types of energy" consist of those that could have been substituted for distillate fuel oil during 1988. The quantities are expressed in thousand barrels, and, therefore, represent the quantity of distillate fuel oil that could have been displaced by the given alternative type of energy.

^b The estimates of total consumption include those quantities that were ascertained switchable or not switchable, plus an additional quantity for which the switching status was not ascertained.

^c "Electricity Receipts" represents those quantities of electricity generated off the manufacturing establishment site and available at the site for consumption. It includes those quantities for which payment was made, quantities transferred in, quantities purchased and paid for by a central purchasing entity, and quantities for which payment was made in kind. It does not include electricity generated onsite. "Electricity Receipts" has not been adjusted to account for any quantities that might have been resold or transferred out. The estimates include those quantities that were ascertained switchable or not switchable, plus an additional quantity for which the switching status was not ascertained.

^d "Other" includes all other types of energy not already identified that respondents indicated could have been consumed in place of distillate fuel oil.

^e See Appendices A and E for descriptions of the Standard Industrial Classification system.

^f Value of Shipments and Employment Size were supplied by the Bureau of the Census. See Appendix A.

*=Estimate less than 0.5 rounded to zero.

W=Withheld to avoid disclosing data for individual establishments. Data are included in higher level totals.

Q=Withheld because Relative Standard Error is greater than 50 percent. Data are included in higher level totals.

Note: Totals may not equal sum of components because of independent rounding.

Source: Energy Information Administration, Office of Energy Markets and End Use, Energy End Use Division, Form EIA-846, "1988 Manufacturing Energy Consumption Survey."

Table 5. Capability to Switch from Residual Fuel Oil to Alternative Energy Sources, 1988
(Thousand Barrels)

Selected Characteristics		Residual Fuel Oil			Alternative Types of Energy ^a					
		Total Consumed ^b	Switchable	Not Switchable	Electricity Receipts ^c	Natural Gas	Distillate Fuel Oil	Coal and Coke	LPG	Other ^d
SIC Code^e	Industry Groups and Industry									
20	Food and Kindred Products	W	5,232	W	139	4,198	1,771	283	281	Q
21	Tobacco Products	217	143	74	0	124	W	W	0	0
22	Textile Mill Products	3,024	1,885	950	Q	1,562	715	203	339	Q
23	Apparel and Other Textile Products	311	228	Q	0	Q	Q	0	Q	0
24	Lumber and Wood Products	458	179	220	0	Q	95	0	Q	Q
25	Furniture and Fixtures	185	101	83	Q	32	72	0	Q	Q
26	Paper and Allied Products	28,274	9,242	18,909	835	7,349	2,430	859	309	217
2621	Paper Mills	15,571	4,419	11,097	W	2,957	1,343	401	W	W
2631	Paperboard Mills	8,515	3,706	4,808	422	3,478	801	370	235	216
27	Printing and Publishing	117	117	0	0	69	59	0	Q	0
28	Chemicals and Allied Products	16,596	7,558	8,804	86	6,088	2,395	262	521	179
2819	Industrial Inorganic Chemicals, nec	1,026	561	464	0	397	94	W	Q	0
2821	Plastics Materials and Resins	W	1,146	W	0	807	801	W	W	0
2869	Industrial Organic Chemicals, nec	3,916	1,088	2,829	W	952	143	W	44	14
2873	Nitrogenous Fertilizers	0	0	0	0	0	0	0	0	0
29	Petroleum and Coal Products	15,703	11,067	4,636	208	8,946	4,465	364	9,074	1,441
2911	Petroleum Refining	15,034	10,891	4,143	208	8,790	4,357	364	8,998	1,441
30	Rubber and Misc. Plastics Products	W	1,779	W	Q	1,469	970	37	163	0
31	Leather and Leather Products	548	307	202	0	Q	Q	Q	0	0
32	Stone, Clay and Glass Products	2,299	1,714	473	Q	1,385	975	125	58	Q
3241	Cement, Hydraulic	Q	Q	Q	0	209	101	125	W	Q
33	Primary Metal Industries	6,239	4,367	1,710	W	2,817	683	960	24	W
3312	Blast Furnaces and Steel Mills	5,754	4,232	1,522	W	2,697	W	W	0	W
3334	Primary Aluminum	2	2	0	0	2	2	0	0	0
34	Fabricated Metal Products	737	366	352	W	213	193	W	Q	W
35	Industrial Machinery and Equipment	556	383	173	Q	301	136	0	Q	W
36	Electronic and Other Electric Equipment	725	386	319	Q	350	211	17	89	W
37	Transportation Equipment	2,970	1,033	1,778	165	751	196	8	68	W
38	Instruments and Related Products	917	504	399	W	460	312	W	Q	0
39	Misc. Manufacturing Industries	195	174	Q	0	116	80	Q	26	0
	Total	90,413	46,767	41,769	2,002	36,611	16,103	3,166	11,217	2,354
Census Region										
	Northeast	35,685	13,968	20,852	577	10,049	5,510	213	2,675	1,384
	Midwest	15,924	11,223	4,449	56	9,410	3,055	928	5,100	295
	South	28,454	14,395	13,363	1,018	11,357	4,328	1,532	1,665	464
	West	10,350	7,181	3,105	351	5,795	3,210	493	1,776	211
	Total	90,413	46,767	41,769	2,002	36,611	16,103	3,166	11,217	2,354
Value of Shipments^f (million dollars)										
	Under 20	6,568	3,091	3,035	67	2,399	1,731	90	474	Q
	20-49	10,057	5,176	4,381	205	3,779	2,544	276	602	244
	50-99	11,928	5,740	5,720	162	3,832	2,525	418	188	66
	100-249	16,548	8,401	7,979	223	7,357	2,604	506	923	261
	250-499	22,916	9,790	13,064	566	8,581	1,903	551	3,120	528
	500 and Over	22,397	14,569	7,589	778	10,663	4,795	1,324	5,910	1,099
	Total	90,413	46,767	41,769	2,002	36,611	16,103	3,166	11,217	2,354
Employment Size^g										
	Under 50	1,642	798	614	0	725	426	0	Q	0
	50-99	4,871	1,914	2,674	Q	1,467	1,141	Q	226	Q
	100-249	14,994	8,919	5,621	178	6,796	4,199	519	2,879	282
	250-499	16,353	8,715	7,230	466	7,159	2,067	705	2,230	450
	500-999	20,445	10,838	9,503	221	8,136	4,046	214	2,613	1,142
	1,000 and Over	32,109	15,584	16,127	1,099	12,329	4,224	1,711	3,159	326
	Total	90,413	46,767	41,769	2,002	36,611	16,103	3,166	11,217	2,354

^a "Alternative types of energy" consist of those that could have been substituted for residual fuel oil during 1988. The quantities are expressed in thousand barrels and, therefore, represent the quantity of residual fuel oil that could have been displaced by the given alternative type of energy.

^b The estimates of total consumption include those quantities that were ascertained switchable or not switchable, plus an additional quantity for which the switching status was not ascertained.

^c "Electricity Receipts" represents those quantities of electricity generated off the manufacturing establishment site and available at the site for consumption. It includes those quantities for which payment was made, quantities transferred in, quantities purchased and paid for by a central purchasing entity, and quantities for which payment was made in kind. It does not include electricity generated onsite. "Electricity Receipts" has not been adjusted to account for any quantities that might have been resold or transferred out. The estimates include those quantities that were ascertained switchable or not switchable, plus an addition quantity for which the switching status was not ascertained.

^d "Other" includes all other types of energy not already identified that respondents indicated could have been consumed in place of residual fuel oil.

^e See Appendices A and E for descriptions of the Standard Industrial Classification system.

^f Value of Shipments and Employment Size were supplied by the Bureau of the Census. See Appendix A.

W=Withheld to avoid disclosing data for individual establishments. Data are included in higher level totals.

Q=Withheld because Relative Standard Error is greater than 50 percent. Data are included in higher level totals.

Note: Totals may not equal sum of components because of independent rounding.

Source: Energy Information Administration, Office of Energy Markets and End Use, Energy End Use Division, Form EIA-845, "1988 Manufacturing Energy Consumption Survey."

Table 6. Capability to Switch from Coal and Coke to Alternative Energy Sources, 1988
(Thousand Short Tons)

Selected Characteristics		Coal and Coke			Alternative Types of Energy ^a					
		Total Consumed ^b	Switchable	Not Switchable	Electricity Receipts ^c	Natural Gas	Distillate Fuel Oil	Residual Fuel Oil	LPG	Other ^d
SIC Code^e	Industry Groups and Industry									
20	Food and Kindred Products	W	W	4,073	289	1,900	1,232	1,213	100	13
21	Tobacco Products	767	W	W	0	3	W	205	0	0
22	Textile Mill Products	1,760	979	781	W	660	454	297	126	23
23	Apparel and Other Textile Products	130	31	Q	Q	Q	Q	Q	Q	0
24	Lumber and Wood Products	106	0	106	0	0	0	0	0	0
25	Furniture and Fixtures	132	57	50	*	24	16	24	16	5
26	Paper and Allied Products	14,036	7,348	6,617	787	3,708	1,649	4,440	142	410
2621	Paper Mills	8,546	4,299	4,185	601	2,468	1,285	2,093	W	292
2631	Paperboard Mills	5,009	2,887	2,113	W	1,198	313	2,246	90	143
27	Printing and Publishing	0	0	0	0	0	0	0	0	0
28	Chemicals and Allied Products	13,269	4,394	8,857	103	2,555	1,417	1,536	293	W
2819	Industrial Inorganic Chemicals, nec	W	W	1,019	0	156	W	W	0	0
2821	Plastics Materials and Resins	1,366	187	1,179	0	149	W	80	W	0
2869	Industrial Organic Chemicals, nec	4,064	1,554	2,510	W	1,421	589	0	W	0
2873	Nitrogenous Fertilizers	0	0	0	0	0	0	0	0	0
29	Petroleum and Coal Products	292	180	112	W	135	175	126	37	W
2911	Petroleum Refining	287	175	112	W	W	W	126	W	W
30	Rubber and Misc. Plastics Products	375	166	175	0	156	15	W	0	0
31	Leather and Leather Products	61	Q	Q	0	Q	0	0	Q	Q
32	Stone, Clay and Glass Products	13,397	6,035	7,324	W	5,231	2,248	1,911	W	865
3241	Cement, Hydraulic	10,004	4,910	5,084	W	4,106	1,980	1,708	W	528
33	Primary Metal Industries	34,189	1,935	32,213	249	1,523	57	434	W	1W
3312	Blast Furnaces and Steel Mills	31,560	1,674	29,881	W	1,476	14	434	W	1W
3334	Primary Aluminum	0	0	0	0	0	0	0	0	0
34	Fabricated Metal Products	456	102	321	W	99	57	36	0	1W
35	Industrial Machinery and Equipment	825	369	454	Q	338	146	86	54	Q
36	Electronic and Other Electric Equipment	333	55	278	0	55	17	18	0	22
37	Transportation Equipment	W	389	W	W	361	103	30	14	0
38	Instruments and Related Products	975	643	332	W	0	W	W	0	0
39	Misc. Manufacturing Industries	82	79	3	0	75	0	47	14	0
	Total	89,968	25,789	63,792	1,758	16,847	7,815	10,885	902	1,600
Census Region										
	Northeast	8,471	2,020	6,435	374	522	567	1,101	53	W
	Midwest	44,804	9,099	35,443	285	7,328	2,547	2,016	347	639
	South	W	W	19,701	826	6,572	3,681	6,496	502	735
	West	W	W	2,212	273	2,425	1,021	1,271	0	W
	Total	89,968	25,789	63,792	1,758	16,847	7,815	10,885	902	1,600
Value of Shipments^f (million dollars)										
	Under 20	4,851	1,734	2,976	105	1,542	594	442	128	W
	20-49	8,647	3,157	5,426	*	2,616	1,284	866	120	335
	50-99	8,889	3,981	4,905	64	3,141	1,525	1,642	Q	456
	100-249	12,647	5,358	7,285	728	3,256	1,535	2,053	185	174
	250-499	15,031	5,787	9,127	518	2,939	1,310	3,282	36	348
	500 and Over	39,902	5,771	34,071	343	3,353	1,567	2,600	400	W
	Total	89,968	25,789	63,792	1,758	16,847	7,815	10,885	902	1,600
Employment Size^f										
	Under 50	668	Q	391	Q	Q	Q	Q	Q	Q
	50-99	3,593	891	2,658	0	782	306	214	W	Q
	100-249	12,242	4,864	7,265	62	3,982	2,137	1,533	154	598
	250-499	10,342	4,745	5,592	467	3,158	1,275	2,342	150	W
	500-999	10,977	5,188	5,754	592	3,116	1,608	1,754	61	554
	1,000 and Over	52,147	9,871	42,131	635	5,579	2,340	4,897	463	398
	Total	89,968	25,789	63,792	1,758	16,847	7,815	10,885	902	1,600

^a "Alternative types of energy" consist of those that could have been substituted for coal and coke during 1988. The quantities are expressed in thousand short tons and, therefore, represent the quantity of coal and coke that could have been displaced by the given alternative type of energy.

^b The estimates of total consumption include those quantities that were ascertained switchable or not switchable, plus an additional quantity for which the switching status was not ascertained.

^c "Electricity Receipts" represents those quantities of electricity generated off the manufacturing establishment site and available at the site for consumption. It includes those quantities for which payment was made, quantities transferred in, quantities purchased and paid for by a central purchasing entity, and quantities for which payment was made in kind. It does not include electricity generated onsite. "Electricity Receipts" has not been adjusted to account for any quantities that might have been resold or transferred out. The estimates include those quantities that were ascertained switchable or not switchable, plus an additional quantity for which the switching status was not ascertained.

^d "Other" includes all other types of energy not already identified that respondents indicated could have been consumed in place of coal and coke.

^e See Appendices A and E for descriptions of the Standard Industrial Classification system.

^f Value of Shipments and Employment Size were supplied by the Bureau of the Census. See Appendix A.

*=Estimate less than 0.5 rounded to zero.

W=Withheld to avoid disclosing data for individual establishments. Data are included in higher level totals.

Q=Withheld because Relative Standard Error greater than 50 percent. Data are included in higher level totals.

Note: Totals may not equal sum of components because of independent rounding.

Source: Energy Information Administration, Office of Energy Markets and End Use, Energy End Use Division, Form EIA-846, "1988 Manufacturing Energy Consumption Survey."

Table 7. Capability to Switch from LPG to Alternative Energy Sources, 1988
(Million Gallons)

Selected Characteristics		LPG			Alternative Types of Energy ^a					
		Total Consumed ^b	Switchable	Not Switchable	Electricity Receipts ^c	Natural Gas	Distillate Fuel Oil	Residual Fuel Oil	Coal and Coke	Other ^d
SIC Code^e	Industry Groups and Industry									
20	Food and Kindred Products	W	22	Q	*	20	10	*	*	*
21	Tobacco Products	1	*	1	0	0	0	0	0	*
22	Textile Mill Products	31	8	22	*	8	*	1	0	*
23	Apparel and Other Textile Products	9	Q	3	Q	Q	*	0	0	*
24	Lumber and Wood Products	39	10	24	*	7	7	Q	0	Q
25	Furniture and Fixtures	14	2	11	*	2	*	*	0	*
26	Paper and Allied Products	53	9	39	1	2	6	*	*	*
2621	Paper Mills	23	6	17	*	1	W	0	0	*
2631	Paperboard Mills	5	1	3	*	1	0	*	0	*
27	Printing and Publishing	18	Q	13	*	Q	*	0	0	Q
28	Chemicals and Allied Products	44	17	23	*	16	1	1	0	1
2819	Industrial Inorganic Chemicals, nec	3	1	2	*	1	1	*	0	*
2821	Plastics Materials and Resins	13	8	5	*	8	*	*	0	*
2869	Industrial Organic Chemicals, nec	8	4	4	*	4	*	*	0	*
2873	Nitrogenous Fertilizers	*	0	*	0	0	0	0	0	0
29	Petroleum and Coal Products	628	417	202	24	407	100	173	18	28
2911	Petroleum Refining	600	411	181	20	401	W	173	W	28
30	Rubber and Misc. Plastics Products	W	3	21	*	2	1	*	0	*
31	Leather and Leather Products	1	*	1	*	*	*	0	0	*
32	Stone, Clay and Glass Products	47	22	20	2	20	3	2	0	1
3241	Cement, Hydraulic	*	*	*	*	*	*	0	0	*
33	Primary Metal Industries	60	24	30	2	22	3	*	*	1
3312	Blast Furnaces and Steel Mills	12	W	W	0	W	*	0	0	*
3334	Primary Aluminum	2	*	1	0	*	*	*	0	0
34	Fabricated Metal Products	49	13	31	2	8	4	*	*	2
35	Industrial Machinery and Equipment	32	6	23	*	4	1	*	0	Q
36	Electronic and Other Electric Equipment	33	Q	19	1	Q	*	*	*	*
37	Transportation Equipment	24	5	15	*	4	*	*	*	*
38	Instruments and Related Products	Q	Q	1	*	*	Q	0	0	*
39	Misc. Manufacturing Industries	6	1	3	*	*	*	0	*	*
	Total	1,226	580	556	37	539	138	181	18	37
Census Region										
	Northeast	W	W	109	6	35	9	1	*	3
	Midwest	W	W	140	18	165	55	82	W	5
	South	291	94	174	4	86	17	5	*	9
	West	432	266	134	9	254	56	93	W	20
	Total	1,226	580	556	37	539	138	181	18	37
Value of Shipments^f (million dollars)										
	Under 20	237	64	145	11	50	17	Q	Q	4
	20-49	164	33	115	2	27	13	2	0	1
	50-99	115	30	61	2	25	6	1	*	2
	100-249	87	43	38	2	37	17	8	*	2
	250-499	146	80	59	2	70	9	46	*	3
	500 and Over	477	330	137	18	330	76	120	W	25
	Total	1,226	580	556	37	539	138	181	18	37
Employment Size^f										
	Under 50	143	23	110	Q	19	10	Q	Q	1
	50-99	67	23	34	1	20	3	1	*	2
	100-249	281	152	112	8	133	57	61	*	2
	250-499	217	107	94	19	98	42	57	W	5
	500-999	222	106	87	2	99	23	W	*	23
	1,000 and Over	296	170	119	1	169	3	W	*	4
	Total	1,226	580	556	37	539	138	181	18	37

^a "Alternative types of energy" consist of those that could have been substituted for LPG during 1988. The quantities are expressed in million gallons and, therefore, represent the quantity of LPG that could have been displaced by the given alternative type of energy.

^b The estimates of total consumption include those quantities that were ascertained switchable or not switchable, plus an additional quantity for which the switching status was not ascertained.

^c "Electricity Receipts" represents those quantities of electricity generated off the manufacturing establishment site and available at the site for consumption. It includes those quantities for which payment was made, quantities transferred in, quantities purchased and paid for by a central purchasing entity, and quantities for which payment was made in kind. It does not include electricity generated onsite. "Electricity Receipts" has not been adjusted to account for any quantities that might have been resold or transferred out. The estimates include those quantities that were ascertained switchable or not switchable, plus an additional quantity for which the switching status was not ascertained.

^d "Other" includes all other types of energy not already identified that respondents indicated could have been consumed in place of LPG.

^e See Appendices A and E for descriptions of the Standard Industrial Classification system.

^f Value of Shipments and Employment Size were supplied by the Bureau of the Census. See Appendix A.

*=Estimate less than 0.5 rounded to zero.

W=Withheld to avoid disclosing data for individual establishments. Data are included in higher level totals.

Q=Withheld because Relative Standard Error is greater than 50 percent. Data are included in higher level totals.

Note: Totals may not equal sum of components because of independent rounding.

Source: Energy Information Administration, Office of Energy Markets and End Use, Energy End Use Division, Form EIA-846, "1988 Manufacturing Energy Consumption Survey."

Table 8. Capability to Switch from Designated Types of Energy by Census Region and Minimum Leadtime to Switch, 1988
(Physical Units)

Type of Energy and Minimum Leadtime to Switch ^b	Quantity Switchable ^a				
	Total United States	Census Region			
		Northeast	Midwest	South	West
Electricity Receipts^c (million kilowatthours)					
Less than one day	6,376	774	2,080	2,813	709
One day through one week	1,879	85	531	858	405
More than one week but within 30 days	2,894	422	910	1,109	454
Leadtime not ascertained	114	Q	60	34	7
Total	11,264	1,293	3,582	4,814	1,575
Natural Gas (billion cubic feet)					
Less than one day	945	131	256	413	144
One day through one week	564	63	144	290	67
More than one week but within 30 days	407	33	159	160	55
Leadtime not ascertained	91	14	27	36	15
Total	2,008	241	586	899	282
Distillate Fuel Oil (thousand barrels)					
Less than one day	4,971	1,471	635	1,916	949
One day through one week	1,313	479	147	542	145
More than one week but within 30 days	2,559	902	953	654	50
Leadtime not ascertained	211	88	46	62	16
Total	9,053	2,940	1,780	3,174	1,159
Residual Fuel Oil (thousand barrels)					
Less than one day	28,669	8,274	6,941	9,649	3,804
One day through one week	12,519	3,852	3,608	2,608	2,451
More than one week but within 30 days	5,193	1,681	640	1,951	Q
Leadtime not ascertained	386	162	33	Q	6
Total	46,767	13,968	11,223	14,395	7,181
Coal and Coke (thousand short tons)					
Less than one day	13,938	1,033	5,257	5,799	1,848
One day through one week	8,235	910	2,819	3,945	560
More than one week but within 30 days	3,475	73	976	W	W
Leadtime not ascertained	142	Q	46	91	Q
Total	25,789	2,020	9,099	W	W
LPG (million gallons)					
Less than one day	390	14	140	49	187
One day through one week	96	W	W	24	Q
More than one week but within 30 days	88	17	16	Q	37
Leadtime not ascertained	6	1	1	2	2
Total	580	W	W	94	265

^a A specific type of energy may be switchable if the combustors had the necessary machinery or equipment in place so that the substitution could have been introduced within 30 days, while holding output constant, and without extensive modifications to the combustor. See Appendix A for more details. The estimates of quantities switchable represent the total consumption during 1988 that could have been replaced by an alternative fuel within the standard leadtime. These amount can also be interpreted as the amount of 1988 consumption that could have been avoided if all possible switching within the leadtime had taken place.

^b "Time to switch" represents the minimum leadtime required to convert to a primary replacement type of energy in place of the indicated type of energy.

^c "Electricity Receipts" represents those quantities of electricity generated off the manufacturing establishment site and available at the site for consumption. It includes those quantities for which payment was made, quantities transferred in, quantities purchased and paid for by a central purchasing entity, and quantities for which payment was made in kind. It does not include electricity generated onsite. "Electricity Receipts" has not been adjusted to account for any quantities that might have been resold or transferred out. The estimates include those quantities that were ascertained switchable or not switchable, plus an additional quantity for which the switching status was not ascertained.

W= Withheld to avoid disclosing data for individual establishments. Data are included in higher level totals.

Q=Withheld because Relative Standard Error is greater than 50 percent. Data are included in higher level totals.

Note: Totals may not equal sum of components because of independent rounding.

Source: Energy Information Administration, Office of Energy Markets and End Use, Energy End Use Division, Form EIA-846, "1988 Manufacturing Energy Consumption Survey."

Table 9. Minimum Leadtime Required to Switch to Electricity from Various Energy Sources Consumed in 1988, by Census Region (Physical Units)

Type of Energy and Minimum Leadtime to Switch ^a	Total United States	Census Region			
		Northeast	Midwest	South	West
From Natural Gas (billion cubic feet)					
Less than one day	41	2	5	27	7
One day through one week	18	1	4	10	3
More than one week but within 30 days	25	4	12	8	1
Leadtime not ascertained	4	Q	1	Q	Q
Total	87	8	21	45	13
From Distillate Fuel Oil (thousand barrels)					
Less than one day	182	29	63	29	Q
One day through one week	Q	Q	Q	2	0
More than one week but within 30 days	313	119	Q	135	0
Leadtime not ascertained	21	Q	1	*	0
Total	540	172	141	167	Q
From Residual Fuel Oil (thousand barrels)					
Less than one day	1,467	W	W	772	293
One day through one week	277	163	Q	54	58
More than one week but within 30 days	249	Q	Q	184	0
Leadtime not ascertained	9	1	0	8	0
Total	2,002	577	56	1,018	351
From Coal and Coke (thousand short tons)					
Less than one day	1,337	240	Q	W	W
One day through one week	402	130	20	W	W
More than one week but within 30 days	19	4	12	Q	0
Leadtime not ascertained	0	0	0	0	0
Total	1,758	374	285	826	273
From LPG (million gallons)					
Less than one day	19	*	W	W	W
One day through one week	Q	*	Q	*	W
More than one week but within 30 days	10	Q	3	W	1
Leadtime not ascertained	1	*	Q	*	*
Total	37	6	18	4	9

^a "Time to Switch" represents the minimum leadtime required to convert to a primary replacement type of energy in place of the indicated type of energy.

*=Estimate less than 0.5 rounded to zero.

W=Withheld to avoid disclosing data for individual establishments. Data are included in higher level totals.

Q=Withheld because Relative Standard Error is greater than 50 percent. Data are included in higher level totals.

Note: Totals may not equal sum of components because of independent rounding.

Source: Energy Information Administration, Office of Energy Markets and End Use, Energy End Use Division, Form EIA-846, "1988 Manufacturing Energy Consumption Survey."

Table 10. Minimum Leadtime Required to Switch to Natural Gas from Various Energy Sources Consumed in 1988, by Census Region (Physical Units)

Type of Energy and Minimum Leadtime to Switch ^a	Total United States	Census Region			
		Northeast	Midwest	South	West
From Electricity Receipts^b (million kilowatthours)					
Less than one day	5,336	W	1,903	2,553	W
One day through one week	1,100	W	309	444	W
More than one week but within 30 days	1,908	369	645	693	201
Leadtime not ascertained	29	Q	Q	13	Q
Total	8,372	765	2,868	3,703	1,037
From Distillate Fuel Oil (thousand barrels)					
Less than one day	4,207	1,280	500	1,723	704
One day through one week	1,057	432	127	472	26
More than one week but within 30 days	996	454	Q	227	56
Leadtime not ascertained	215	90	42	67	15
Total	6,475	2,256	928	2,490	801
From Residual Fuel Oil (thousand barrels)					
Less than one day	24,490	6,765	6,155	8,273	3,298
One day through one week	8,932	2,239	2,780	1,960	1,954
More than one week but within 30 days	2,799	899	455	942	504
Leadtime not ascertained	390	146	20	Q	42
Total	36,611	10,049	9,410	11,357	5,795
From Coal and Coke (thousand short tons)					
Less than one day	8,866	318	3,842	3,080	1,626
One day through one week	5,064	W	2,558	2,090	W
More than one week but within 30 days	2,763	Q	876	1,303	W
Leadtime not ascertained	155	Q	52	98	Q
Total	16,847	522	7,328	6,572	2,425
From LPG (million gallons)					
Less than one day	367	11	135	47	174
One day through one week	100	13	16	22	49
More than one week but within 30 days	66	10	13	Q	29
Leadtime not ascertained	7	1	1	2	3
Total	539	35	165	86	254

^a "Time to Switch" represents the minimum leadtime required to convert to a primary replacement type of energy in place of the indicated type of energy.

^b "Electricity Receipts" represents those quantities of electricity generated off the manufacturing establishment site and available at the site for consumption. It includes those quantities for which payment was made, quantities transferred in, quantities purchased and paid for by a central purchasing entity, and quantities for which payment was made in kind. It does not include electricity generated onsite. "Electricity Receipts" has not been adjusted to account for any quantities that might have been resold or transferred out. The estimates include those quantities that were ascertained switchable or not switchable, plus an additional quantity for which the switching status was not ascertained.

W=Withheld to avoid disclosing data for individual establishments. Data are included in higher level totals.

Q=Withheld because Relative Standard Error is greater than 50 percent. Data are included in higher level totals.

Note: Totals may not equal sum of components because of independent rounding.

Source: Energy Information Administration, Office of Energy Markets and End Use, Energy End Use Division, Form EIA-846, "1988 Manufacturing Energy Consumption Survey."

Table 11. Minimum Leadtime Required to Switch to Distillate Fuel Oil from Various Energy Sources Consumed in 1988, by Census Region (Physical Units)

Type of Energy and Minimum Leadtime to Switch ^a	Total United States	Census Region			
		Northeast	Midwest	South	West
From Electricity Receipts^b (million kilowatthours)					
Less than one day	902	117	201	353	231
One day through one week	713	73	225	249	166
More than one week but within 30 days	1,561	153	480	601	326
Leadtime not ascertained	51	Q	35	Q	*
Total	3,228	349	941	1,213	724
From Natural Gas (billion cubic feet)					
Less than one day	353	50	101	149	53
One day through one week	278	31	74	136	38
More than one week but within 30 days	203	23	69	74	38
Leadtime not ascertained	53	8	14	22	9
Total	888	111	258	380	138
From Residual Fuel Oil (thousand barrels)					
Less than one day	4,254	1,244	856	1,209	945
One day through one week	4,815	2,204	210	1,201	1,200
More than one week but within 30 days	6,771	1,969	1,966	1,790	1,046
Leadtime not ascertained	263	93	23	Q	20
Total	16,103	5,510	3,055	4,328	3,210
From Coal and Coke (thousand short tons)					
Less than one day	2,716	W	1,244	1,092	W
One day through one week	1,954	W	W	1,004	W
More than one week but within 30 days	3,036	24	618	1,515	879
Leadtime not ascertained	109	Q	W	70	0
Total	7,815	567	2,547	3,681	1,021
From LPG (million gallons)					
Less than one day	61	4	18	4	35
One day through one week	40	1	22	4	13
More than one week but within 30 days	36	4	15	8	9
Leadtime not ascertained	2	*	Q	1	*
Total	138	9	55	17	56

^a "Time to Switch" represents the minimum leadtime required to convert to a primary replacement type of energy in place of the indicated type of energy.

^b "Electricity Receipts" represents those quantities of electricity generated off the manufacturing establishment site and available at the site for consumption. It includes those quantities for which payment was made, quantities transferred in, quantities purchased and paid for by a central purchasing entity, and quantities for which payment was made in kind. It does not include electricity generated onsite. "Electricity Receipts" has not been adjusted to account for any quantities that might have been resold or transferred out. The estimates include those quantities that were ascertained switchable or not switchable, plus an additional quantity for which the switching status was not ascertained.

*=Estimate less than 0.5 rounded to zero.

W=Withheld to avoid disclosing data for individual establishments. Data are included in higher level totals.

Q=Withheld because Relative Standard Error is greater than 50 percent. Data are included in higher level totals.

Note: Totals may not equal sum of components because of independent rounding.

Source: Energy Information Administration, Office of Energy Markets and End Use, Energy End Use Division, Form EIA-846, "1988 Manufacturing Energy Consumption Survey."

Table 12. Minimum Leadtime Required to Switch to Residual Fuel Oil from Various Energy Sources Consumed in 1988, by Census Region (Physical Units)

Type of Energy and Minimum Leadtime to Switch ^a	Total United States	Census Region			
		Northeast	Midwest	South	West
From Electricity Receipts^b (million kilowatthours)					
Less than one day	2,568	614	719	968	267
One day through one week	1,053	W	544	361	W
More than one week but within 30 days	977	W	548	110	W
Leadtime not ascertained	20	Q	Q	Q	Q
Total	4,619	763	1,820	1,446	590
From Natural Gas (billion cubic feet)					
Less than one day	335	68	75	142	50
One day through one week	200	27	53	82	39
More than one week but within 30 days	214	14	83	96	21
Leadtime not ascertained	37	6	10	16	9
Total	786	117	221	336	119
From Distillate Fuel Oil (thousand barrels)					
Less than one day	365	60	Q	137	148
One day through one week	403	101	W	247	W
More than one week but within 30 days	1,594	556	Q	330	W
Leadtime not ascertained	35	27	2	6	0
Total	2,397	744	Q	720	202
From Coal and Coke (thousand short tons)					
Less than one day	4,501	W	801	2,682	W
One day through one week	4,480	622	532	2,806	620
More than one week but within 30 days	1,705	W	637	858	W
Leadtime not ascertained	199	Q	46	150	0
Total	10,885	1,101	2,016	6,496	1,270
From LPG (million gallons)					
Less than one day	126	0	46	1	79
One day through one week	37	0	30	W	W
More than one week but within 30 days	17	1	5	W	W
Leadtime not ascertained	0	0	0	0	0
Total	181	1	82	5	99

^a "Time to Switch" represents the minimum leadtime required to convert to a primary replacement type of energy in place of the indicated type of energy.

^b "Electricity Receipts" represents those quantities of electricity generated off the manufacturing establishment site and available at the site for consumption. It includes those quantities for which payment was made, quantities transferred in, quantities purchased and paid for by a central purchasing entity, and quantities for which payment was made in kind. It does not include electricity generated onsite. "Electricity Receipts" has not been adjusted to account for any quantities that might have been resold or transferred out. The estimates include those quantities that were ascertained switchable or not switchable, plus an additional quantity for which the switching status was not ascertained.

W=Estimate less than 0.5 rounded to zero.

W=Withheld to avoid disclosing data for individual establishments. Data are included in higher level totals.

Q=Withheld because Relative Standard Error is greater than 50 percent. Data are included in higher level totals.

Note: Totals may not equal sum of components because of independent rounding.

Source: Energy Information Administration, Office of Energy Markets and End Use, Energy End Use Division, Form EIA-846, "1988 Manufacturing Energy Consumption Survey."

Table 13. Minimum Leadtime Required to Switch to Coal and Coke from Various Energy Sources Consumed In 1988, by Census Region (Physical Units)

Type of Energy and Minimum Leadtime to Switch ^a	Total United States	Census Region			
		Northeast	Midwest	South	West
From Electricity Receipts^b (million kilowatthours)					
Less than one day	530	33	76	W	W
One day through one week	443	W	W	219	0
More than one week but within 30 days	215	Q	Q	140	Q
Leadtime not ascertained	W	0	0	W	0
Total	1,198	W	318	701	W
From Natural Gas (billion cubic feet)					
Less than one day	38	1	14	16	7
One day through one week	31	Q	10	18	W
More than one week but within 30 days	35	W	20	9	W
Leadtime not ascertained	5	1	2	2	*
Total	108	6	46	46	11
From Distillate Fuel Oil (thousand barrels)					
Less than one day	272	Q	68	56	97
One day through one week	Q	0	Q	*	0
More than one week but within 30 days	150	Q	Q	90	Q
Leadtime not ascertained	Q	Q	W	4	0
Total	460	99	111	151	100
From Residual Fuel Oil (thousand barrels)					
Less than one day	1,548	116	90	901	442
One day through one week	1,400	W	W	555	W
More than one week but within 30 days	198	W	W	75	0
Leadtime not ascertained	Q	Q	3	1	0
Total	3,166	213	928	1,532	493
From LPG (million gallons)					
Less than one day	W	0	W	*	W
One day through one week	Q	*	Q	0	0
More than one week but within 30 days	*	*	*	*	0
Leadtime not ascertained	*	0	0	0	*
Total	18	*	W	*	W

^a "Time to Switch" represents the minimum leadtime required to convert to a primary replacement type of energy in place of the indicated type of energy.

^b "Electricity Receipts" represents those quantities of electricity generated off the manufacturing establishment site and available at the site for consumption. It includes those quantities for which payment was made, quantities transferred in, quantities purchased and paid for by a central purchasing entity, and quantities for which payment was made in kind. It does not include electricity generated onsite. "Electricity Receipts" has not been adjusted to account for any quantities that might have been resold or transferred out. The estimates include those quantities that were ascertained switchable or not switchable, plus an additional quantity for which the switching status was not ascertained.

*=Estimate less than 0.5 rounded to zero.

W=Withheld to avoid disclosing data for individual establishments. Data are included in higher level totals.

Q=Withheld because Relative Standard Error is greater than 50 percent. Data are included in higher level totals.

Note: Totals may not equal sum of components because of independent rounding.

Source: Energy Information Administration, Office of Energy Markets and End Use, Energy End Use Division, Form EIA-846, "1988 Manufacturing Energy Consumption Survey."

Table 14. Minimum Leadtime Required to Switch to LPG from Various Energy Sources Consumed in 1988, by Census Region
(Physical Units)

Type of Energy and Minimum Leadtime to Switch ^a	Total United States	Census Region			
		Northeast	Midwest	South	West
From Electricity Receipts^b (million kilowatthours)					
Less than one day	371	W	W	66	237
One day through one week	825	W	W	192	122
More than one week but within 30 days	1,144	Q	W	375	177
Leadtime not ascertained	15	Q	Q	3	0
Total	2,355	600	583	636	536
From Natural Gas (billion cubic feet)					
Less than one day	296	27	94	125	50
One day through one week	174	14	35	111	13
More than one week but within 30 days	169	16	54	77	22
Leadtime not ascertained	32	3	8	15	6
Total	670	60	192	327	91
From Distillate Fuel Oil (thousand barrels)					
Less than one day	450	48	123	114	165
One day through one week	318	35	W	42	W
More than one week but within 30 days	1,412	352	Q	472	W
Leadtime not ascertained	72	27	Q	27	1
Total	2,253	463	Q	656	336
From Residual Fuel Oil (thousand barrels)					
Less than one day	4,973	775	2,663	427	1,108
One day through one week	4,523	W	2,282	437	W
More than one week but within 30 days	1,609	W	155	689	W
Leadtime not ascertained	Q	0	0	Q	0
Total	11,217	2,675	5,100	1,665	1,776
From Coal and Coke (thousand short tons)					
Less than one day	57	0	W	W	0
One day through one week	233	W	W	W	0
More than one week but within 30 days	567	45	161	362	0
Leadtime not ascertained	45	Q	W	0	0
Total	902	53	347	502	0

^a "Time to Switch" represents the minimum leadtime required to convert to a primary replacement type of energy in place of the indicated type of energy.

^b "Electricity Receipts" represents those quantities of electricity generated off the manufacturing establishment site and available at the site for consumption. It includes those quantities for which payment was made, quantities transferred in, quantities purchased and paid for by a central purchasing entity, and quantities for which payment was made in kind. It does not include electricity generated onsite. "Electricity Receipts" has not been adjusted to account for any quantities that might have been resold or transferred out. The estimates include those quantities that were ascertained switchable or not switchable, plus an additional quantity for which the switching status was not ascertained.

W=Withheld to avoid disclosing data for individual establishments. Data are included in higher level totals.

Q=Withheld because Relative Standard Error is greater than 50 percent. Data are included in higher level totals.

Note: Totals may not equal sum of components because of independent rounding.

Source: Energy Information Administration, Office of Energy Markets and End Use, Energy End Use Division, Form EIA-846, "1988 Manufacturing Energy Consumption Survey."

**Relative
Standard
Errors**

**Table 15. Relative Standard Errors for Table 1
(Percent)**

Type of Energy	Actual Consumption	Minimum Consumption ^a	Maximum Consumption ^b
Total United States			
Electricity Receipts ^c (million kilowatthours)	2	2	2
Natural Gas (billion cubic feet)	2	3	2
Distillate Fuel Oil (thousand barrels)	6	8	2
Residual Fuel Oil (thousand barrels)	3	4	2
Coal and Coke (thousand short tons)	3	4	3
LPG (million gallons)	5	7	3
Northeast Census Region			
Electricity Receipts ^c (million kilowatthours)	3	3	3
Natural Gas (billion cubic feet)	4	6	3
Distillate Fuel Oil (thousand barrels)	9	11	4
Residual Fuel Oil (thousand barrels)	4	5	4
Coal and Coke (thousand short tons)	7	8	7
LPG (million gallons)	W	9	6
Midwest Census Region			
Electricity Receipts ^c (million kilowatthours)	3	3	3
Natural Gas (billion cubic feet)	2	3	2
Distillate Fuel Oil (thousand barrels)	10	11	3
Residual Fuel Oil (thousand barrels)	8	22	4
Coal and Coke (thousand short tons)	4	5	4
LPG (million gallons)	W	19	4
South Census Region			
Electricity Receipts ^c (million kilowatthours)	2	2	2
Natural Gas (billion cubic feet)	4	5	3
Distillate Fuel Oil (thousand barrels)	14	18	4
Residual Fuel Oil (thousand barrels)	4	6	3
Coal and Coke (thousand short tons)	W	6	4
LPG (million gallons)	7	8	5
West Census Region			
Electricity Receipts ^c (million kilowatthours)	3	3	3
Natural Gas (billion cubic feet)	4	6	3
Distillate Fuel Oil (thousand barrels)	8	10	5
Residual Fuel Oil (thousand barrels)	7	12	4
Coal and Coke (thousand short tons)	W	10	7
LPG (million gallons)	9	12	5

^a Minimum consumption represents actual 1988 consumption decreased by the quantity of the designated type of energy that would no longer have been required if all ascertained switching from that type of energy had occurred. The minimum value includes the quantity of 1988 consumption for which switching capability was not ascertained.

^b Maximum consumption represents actual 1988 consumption increased by the quantity of the designated type of energy that would have been required if all ascertained switching into that type of energy had occurred. This value assumes that all indicated substitutions were possible simultaneously and the substitutable amount consists of the sum of all possible switches to the designated type of energy. The estimate assumes that 1988 output remained constant.

^c "Electricity Receipts" represents those quantities of electricity generated off the manufacturing establishment site and available at the site for consumption. It includes those quantities for which payment was made, quantities transferred in, quantities purchased and paid for by a central purchasing entity, and quantities for which payment was made in kind. It does not include electricity generated onsite. "Electricity Receipts" has not been adjusted to account for any quantities that might have been resold or transferred out. The estimates include those quantities that were ascertained switchable or not switchable, plus an additional quantity for which the switching status was not ascertained.

W=Withheld to avoid disclosing data for individual establishments. Data are included in higher level totals.

Source: Energy Information Administration, Office of Energy Markets and End Use, Energy End Use Division, Form EIA-846, "1988 Manufacturing Energy Consumption Survey."

Table 16. Relative Standard Errors for Table 2
(Percent)

Selected Characteristics		Electricity Receipts			Alternative Types of Energy ^a					
		Total Receipts ^b	Switchable	Not Switchable	Natural Gas	Distillate Fuel Oil	Residual Fuel Oil	Coal and Coke	LPG	Other ^c
SIC Code^d	Industry Groups and Industry									
20	Food and Kindred Products	4	22	4	28	30	35	22	Q	30
21	Tobacco Products	8	W	W	0	0	0	W	0	0
22	Textile Mill Products	4	34	4	Q	46	0	W	0	0
23	Apparel and Other Textile Products	10	Q	10	Q	0	0	0	Q	0
24	Lumber and Wood Products	8	Q	8	Q	Q	Q	0	0	Q
25	Furniture and Fixtures	8	40	9	Q	0	Q	41	46	0
26	Paper and Allied Products	3	9	3	12	35	11	20	0	43
2621	Paper Mills	3	11	3	13	W	W	W	0	W
2631	Paperboard Mills	5	12	5	14	28	17	18	0	W
27	Printing and Publishing	7	Q	7	Q	Q	0	Q	0	0
28	Chemicals and Allied Products	4	11	4	15	23	13	11	Q	26
2819	Industrial Inorganic Chemicals, nec	13	W	13	W	0	W	0	0	0
2821	Plastics Materials and Resins	5	14	5	W	W	W	W	W	0
2869	Industrial Organic Chemicals, nec	7	20	7	26	36	29	29	0	31
2873	Nitrogenous Fertilizers	7	22	7	W	W	0	W	0	0
29	Petroleum and Coal Products	4	6	4	7	9	9	29	8	16
2911	Petroleum Refining	4	6	4	7	8	9	W	W	16
30	Rubber and Misc. Plastics Products	5	28	5	33	48	43	0	45	Q
31	Leather and Leather Products	22	35	26	Q	W	*	0	Q	Q
32	Stone, Clay and Glass Products	3	15	3	20	21	33	43	29	30
3241	Cement, Hydraulic	5	W	5	W	W	0	0	W	0
33	Primary Metal Industries	3	10	3	10	20	10	Q	W	*
3312	Blast Furnaces and Steel Mills	4	10	4	10	W	10	0	W	0
3334	Primary Aluminum	6	0	6	0	0	0	0	0	0
34	Fabricated Metal Products	5	40	5	Q	44	Q	0	Q	*
35	Industrial Machinery and Equipment	5	30	6	40	39	Q	Q	Q	0
36	Electronic and Other Electric Equipment	5	43	5	50	47	Q	Q	Q	W
37	Transportation Equipment	5	15	5	28	18	W	0	39	W
38	Instruments and Related Products	7	32	8	Q	Q	37	W	Q	0
39	Misc. Manufacturing Industries	8	Q	W	Q	Q	Q	Q	Q	0
	Total	2	5	2	6	10	7	11	12	15
Census Region										
	Northeast	3	16	3	23	23	14	49	28	19
	Midwest	3	8	3	9	13	10	25	18	19
	South	2	8	2	9	18	13	12	28	26
	West	3	17	3	18	25	17	21	14	17
	Total	2	5	2	6	10	7	11	12	15
Value of Shipments^e (million dollars)										
	Under 20	3	22	4	29	25	37	36	42	Q
	20-49	3	17	3	22	24	42	Q	37	30
	50-99	3	28	3	29	42	14	19	29	40
	100-249	3	12	3	15	22	16	18	38	32
	250-499	4	9	4	10	21	11	18	15	16
	500 and Over	3	7	3	8	17	9	12	15	15
	Total	2	5	2	6	10	7	11	12	15
Employment Size^e										
	Under 50	6	28	6	35	30	40	41	41	Q
	50-99	5	25	5	23	45	Q	39	49	Q
	100-249	3	17	3	22	28	25	44	35	26
	250-499	2	12	3	14	17	14	15	17	18
	500-999	3	8	3	10	17	14	19	35	20
	1,000 and Over	3	7	3	9	18	8	13	18	17
	Total	2	5	2	6	10	7	11	12	15

^a "Alternative types of energy" consist of those that could have been substituted for electricity receipts during 1988. The quantities are expressed as the percent of electricity that could have been displaced by the given alternative type of energy.

^b "Total Receipts" represents those quantities of electricity generated off the manufacturing establishment site and available at the site for consumption. It includes those quantities for which payment was made, quantities transferred in, quantities purchased and paid for by a central purchasing entity, and quantities for which payment was made in kind. It does not include electricity generated onsite. "Electricity Receipts" has not been adjusted to account for any quantities that might have been resold or transferred out. The estimates include those quantities that were ascertained switchable or not switchable, plus an additional quantity for which the switching status was not ascertained.

^c "Other" includes all other types of energy not already identified that respondents indicated could have been consumed in place of electricity.

^d See Appendices A and E for descriptions of the Standard Industrial Classification system.

^e Value of Shipments and Employment Size were supplied by the Bureau of the Census. See Appendix A.

*=Estimate less than 0.5 rounded to zero.

W=Withheld to avoid disclosing data for individual establishments. Data are included in higher level totals.

Q=Withheld because Relative Standard Error is greater than 50 percent. Data are included in higher level totals.

Source: Energy Information Administration, Office of Energy Markets and End Use, Energy End Use Division, Form EIA-846, "1988 Manufacturing Energy Consumption Survey."

Table 17. Relative Standard Errors for Table 3
(Percent)

Selected Characteristics		Natural Gas			Alternative Types of Energy ^a					
		Total Consumed ^b	Switchable	Not Switchable	Electricity Receipts ^c	Distillate Fuel Oil	Residual Fuel Oil	Coal and Coke	LPG	Other ^d
SIC Code^e	Industry Groups and Industry									
20	Food and Kindred Products	3	4	5	27	5	5	14	7	30
21	Tobacco Products	12	15	14	0	19	23	*	*	0
22	Textile Mill Products	5	6	9	29	9	9	13	10	21
23	Apparel and Other Textile Products	16	20	22	Q	24	32	*	38	0
24	Lumber and Wood Products	12	16	16	44	33	32	*	22	48
25	Furniture and Fixtures	8	14	10	*	26	33	*	18	*
26	Paper and Allied Products	3	4	4	10	5	4	8	11	21
2621	Paper Mills	3	4	5	12	5	4	10	9	*
2631	Paperboard Mills	6	6	8	17	11	7	12	17	27
27	Printing and Publishing	8	14	11	31	20	26	*	18	*
28	Chemicals and Allied Products	6	5	7	17	6	5	14	10	17
2819	Industrial Inorganic Chemicals, nec	W	13	W	27	15	17	27	18	*
2821	Plastics Materials and Resins	W	7	W	*	9	8	W	18	0
2869	Industrial Organic Chemicals, nec	12	10	14	28	10	11	27	16	23
2873	Nitrogenous Fertilizers	9	13	9	0	14	W	0	*	0
29	Petroleum and Coal Products	5	5	6	13	8	7	22	6	18
2911	Petroleum Refining	5	6	7	13	10	7	16	6	19
30	Rubber and Misc. Plastics Products	5	6	10	21	7	9	26	12	38
31	Leather and Leather Products	12	17	19	*	25	22	*	*	*
32	Stone, Clay and Glass Products	4	5	6	16	6	8	11	7	22
3241	Cement, Hydraulic	9	11	8	Q	11	9	12	18	20
33	Primary Metal Industries	3	4	4	14	7	7	12	6	W
3312	Blast Furnaces and Steel Mills	4	6	5	W	8	8	13	11	W
3334	Primary Aluminum	6	7	8	0	9	12	0	9	0
34	Fabricated Metal Products	6	7	9	19	11	11	22	9	48
35	Industrial Machinery and Equipment	9	7	14	21	8	12	27	10	W
36	Electronic and Other Electric Equipment	5	6	7	25	9	12	35	9	*
37	Transportation Equipment	6	6	9	18	6	13	14	8	*
38	Instruments and Related Products	9	12	13	Q	14	15	0	24	*
39	Misc. Manufacturing Industries	11	14	16	*	21	17	*	23	*
	Total	2	2	3	6	2	2	5	3	9
Census Region										
	Northeast	4	4	6	12	6	5	14	6	21
	Midwest	2	3	3	14	4	4	7	4	14
	South	4	3	5	9	4	4	8	5	12
	West	4	4	6	15	5	5	12	6	22
	Total	2	2	3	6	2	2	5	3	9
Value of Shipments^f (million dollars)										
	Under 20	4	5	6	14	7	9	13	8	29
	20-49	3	4	4	13	5	6	11	7	22
	50-99	3	3	5	18	4	5	11	5	20
	100-249	4	3	6	19	5	4	11	5	14
	250-499	3	4	5	16	5	5	10	8	28
	500 and Over	5	4	7	11	6	5	10	6	14
	Total	2	2	3	6	2	2	5	3	9
Employment Size^g										
	Under 50	7	7	10	21	9	12	29	11	39
	50-99	4	6	6	22	8	10	15	10	31
	100-249	4	4	5	16	4	6	11	6	24
	250-499	3	3	4	18	5	4	10	5	19
	500-999	3	3	4	12	4	4	9	5	17
	1,000 and Over	5	4	7	10	5	4	8	7	16
	Total	2	2	3	6	2	2	5	3	9

^a "Alternative types of energy" consist of those that could have been substituted for natural gas during 1988. The quantities are expressed as the percent of natural gas that could have been displaced by the given alternative type of energy.

^b The estimates of total consumption include those quantities that were ascertained switchable or not switchable, plus an additional quantity for which the switching status was not ascertained.

^c "Electricity Receipts" represents those quantities of electricity generated off the manufacturing establishment site and available at the site for consumption. It includes those quantities for which payment was made, quantities transferred in, quantities purchased and paid for by a central purchasing entity, and quantities for which payment was made in kind. It does not include electricity generated onsite. "Electricity Receipts" has not been adjusted to account for any quantities that might have been resold or transferred out. The estimates include those quantities that were ascertained switchable or not switchable, plus an additional quantity for which the switching status was not ascertained.

^d "Other" includes all other types of energy not already identified that respondents indicated could have been consumed in place of natural gas.

^e See Appendices A and E for descriptions of the Standard Industrial Classification system.

^f Value of Shipments and Employment Size were supplied by the Bureau of the Census. See Appendix A.

^g * = Estimate less than 0.5 rounded to zero.

W = Withheld to avoid disclosing data for individual establishments. Data are included in higher level totals.

Q = Withheld because Relative Standard Error is greater than 50 percent. Data are included in higher level totals.

Source: Energy Information Administration, Office of Energy Markets and End Use, Energy End Use Division, Form EIA-846, "1988 Manufacturing Energy Consumption Survey."

**Table 18. Relative Standard Errors for Table 4
(Percent)**

Selected Characteristics		Distillate Fuel Oil			Alternative Types of Energy ^a					
		Total Consumed ^b	Switchable	Not Switchable	Electricity Receipts ^c	Natural Gas	Residual Fuel Oil	Coal and Coke	LPG	Other ^d
SIC Code^e	Industry Groups and Industry									
20	Food and Kindred Products	W	20	13	Q	23	39	Q	31	Q
21	Tobacco Products	18	17	26	Q	18	*	Q	29	Q
22	Textile and Mill Products	18	31	22	Q	32	29	44	26	33
23	Apparel and Other Textile Products	22	Q	26	Q	Q	Q	Q	Q	Q
24	Lumber and Wood Products	22	46	26	Q	Q	Q	Q	Q	50
25	Furniture and Fixtures	33	Q	26	*	43	Q	Q	Q	Q
26	Paper and Allied Products	9	8	11	28	11	14	27	18	W
2621	Paper Mills	5	7	6	W	9	15	16	15	W
2631	Paperboard Mills	18	14	21	26	17	22	W	31	Q
27	Printing and Publishing	20	26	30	Q	27	32	Q	Q	Q
28	Chemicals and Allied Products	10	17	11	21	16	46	13	45	13
2819	Industrial Inorganic Chemicals, nec	W	15	19	Q	16	31	W	27	Q
2821	Plastics Materials and Resins	17	26	18	W	27	13	Q	15	W
2869	Industrial Organic Chemicals, nec	10	20	12	25	20	41	W	23	W
2873	Nitrogenous Fertilizers	11	21	14	Q	W	W	Q	Q	Q
29	Petroleum and Coal Products	18	29	24	41	25	41	43	42	21
2911	Petroleum Refining	11	9	15	W	11	14	22	10	15
30	Rubber and Misc. Plastics Products	15	20	22	Q	19	46	Q	Q	Q
31	Leather and Leather Products	31	Q	22	Q	Q	Q	Q	Q	Q
32	Stone, Clay and Glass Products	25	20	35	Q	24	23	26	26	Q
3241	Cement, Hydraulic	6	17	7	Q	23	22	W	21	Q
33	Primary Metal Industries	8	21	8	21	21	Q	*	Q	21
3312	Blast Furnaces and Steel Mills	6	15	6	*	15	Q	Q	14	W
3334	Primary Aluminum	8	16	9	W	16	Q	Q	W	Q
34	Fabricated Metal Products	14	28	17	Q	30	36	Q	36	Q
35	Industrial Machinery and Equipment	18	22	26	31	23	37	Q	42	Q
36	Electronic and Other Electric Equipment	16	21	26	Q	22	35	32	31	Q
37	Transportation Equipment	W	W	14	28	23	25	21	Q	W
38	Instruments and Related Products	28	26	31	*	26	Q	Q	Q	Q
39	Misc. Manufacturing Industries	18	28	24	Q	37	33	Q	Q	Q
	Total	6	8	9	19	7	20	15	20	22
Census Region										
	Northeast	9	10	12	33	10	21	37	20	10
	Midwest	10	26	12	32	21	Q	26	Q	20
	South	14	12	21	34	14	20	27	26	14
	West	8	11	11	Q	12	16	24	15	22
	Total	6	8	9	19	7	20	15	20	22
Value of Shipments^f (million dollars)										
	Under 20	12	19	17	28	17	37	31	37	Q
	20-49	8	14	9	49	16	26	43	25	Q
	50-99	11	11	13	20	13	19	21	26	20
	100-249	8	18	9	19	9	43	13	13	13
	250-499	7	11	8	41	13	16	29	15	9
	500 and Over	6	12	8	20	14	14	22	12	9
	Total	6	8	9	19	7	20	15	20	22
Employment Size^g										
	Under 50	18	27	23	33	24	42	37	50	40
	50-99	10	20	12	Q	19	23	Q	49	22
	100-249	7	11	9	42	12	17	19	16	31
	250-499	9	18	10	Q	21	28	Q	26	43
	500-999	11	11	12	15	9	43	14	11	17
	1,000 and Over	5	10	6	35	12	18	20	21	20
	Total	6	8	9	19	7	20	15	20	22

^a "Alternative types of energy" consist of those that could have been substituted for distillate fuel oil during 1988. The quantities are expressed as the percent of distillate fuel oil that could have been displaced by the given alternative type of energy.

^b The estimates of total consumption include those quantities that were ascertained switchable or not switchable, plus an additional quantity for which the switching status was not ascertained.

^c "Electricity Receipts" represents those quantities of electricity generated off the manufacturing establishment site and available at the site for consumption. It includes those quantities for which payment was made, quantities transferred in, quantities purchased and paid for by a central purchasing entity, and quantities for which payment was made in kind. It does not include electricity generated onsite. "Electricity Receipts" has not been adjusted to account for any quantities that might have been resold or transferred out. The estimates include those quantities that were ascertained switchable or not switchable, plus an additional quantity for which the switching status was not ascertained.

^d "Other" includes all other types of energy not already identified that respondents indicated could have been consumed in place of distillate fuel oil.

^e See Appendices A and E for descriptions of the Standard Industrial Classification system.

^f Value of Shipments and Employment Size were supplied by the Bureau of the Census. See Appendix A.

*=Estimate less than 0.5 rounded to zero.

W=Withheld to avoid disclosing data for individual establishments. Data are included in higher level totals.

Q=Withheld because Relative Standard Error is greater than 50 percent. Data are included in higher level totals.

Source: Energy Information Administration, Office of Energy Markets and End Use, Energy End Use Division, Form EIA-846, "1988 Manufacturing Energy Consumption Survey."

**Table 19. Relative Standard Errors for Table 5
(Percent)**

Selected Characteristics		Residual Fuel Oil			Alternative Types of Energy ^a					
		Total Consumed ^b	Switchable	Not Switchable	Electricity Receipts ^c	Natural Gas	Distillate Fuel Oil	Coal and Coke	LPG	Other ^d
SIC Code^e	Industry Groups and Industry									
20	Food and Kindred Products	W	11	W	37	8	29	20	21	Q
21	Tobacco Products	10	12	17	0	13	W	W	0	0
22	Textile Mill Products	6	8	12	Q	8	13	17	24	Q
23	Apparel and Other Textile Products	33	43	Q	0	Q	Q	0	Q	0
24	Lumber and Wood Products	29	38	43	0	Q	37	0	Q	Q
25	Furniture and Fixtures	23	31	34	Q	40	39	0	Q	Q
26	Paper and Allied Products	4	4	5	11	5	7	11	22	25
2621	Paper Mills	5	5	6	W	6	9	15	W	W
2631	Paperboard Mills	7	7	9	19	8	13	18	21	25
27	Printing and Publishing	28	28	0	0	27	46	0	Q	0
28	Chemicals and Allied Products	8	6	14	39	6	14	15	25	39
2819	Industrial Inorganic Chemicals, nec	10	14	15	0	17	25	W	Q	0
2821	Plastics Materials and Resins	W	11	W	0	12	15	W	W	0
2869	Industrial Organic Chemicals, nec	15	15	18	W	17	15	W	30	39
2873	Nitrogenous Fertilizers	0	0	0	0	0	0	0	0	0
29	Petroleum and Coal Products	6	7	10	21	7	11	18	8	18
2911	Petroleum Refining	6	7	10	21	7	12	18	8	18
30	Rubber and Misc. Plastics Products	W	10	W	Q	11	13	36	32	0
31	Leather and Leather Products	31	48	35	0	Q	Q	Q	0	0
32	Stone, Clay and Glass Products	16	16	42	Q	14	17	15	32	Q
3241	Cement, Hydraulic	Q	Q	Q	0	35	28	15	W	Q
33	Primary Metal Industries	8	8	11	W	10	16	17	32	W
3312	Blast Furnaces and Steel Mills	8	8	11	W	10	W	W	0	W
3334	Primary Aluminum	23	23	0	0	23	23	0	0	0
34	Fabricated Metal Products	19	25	29	W	27	44	W	Q	W
35	Industrial Machinery and Equipment	16	16	32	Q	18	28	0	Q	W
36	Electronic and Other Electric Equipment	13	17	22	Q	17	25	39	38	W
37	Transportation Equipment	12	27	10	26	36	21	30	13	W
38	Instruments and Related Products	14	14	23	W	15	20	W	Q	0
39	Misc. Manufacturing Industries	18	19	Q	0	22	31	Q	39	0
	Total	3	3	4	8	3	6	7	7	13
Census Region										
	Northeast	4	5	5	12	6	8	14	13	20
	Midwest	8	6	23	38	7	14	18	11	20
	South	4	4	6	12	4	8	8	12	21
	West	7	8	13	21	6	16	15	9	25
	Total	3	3	4	8	3	6	7	7	13
Value of Shipments^f (million dollars)										
	Under 20	9	13	14	49	14	17	24	29	Q
	20-49	12	11	24	27	7	20	18	21	35
	50-99	6	7	9	22	7	13	16	17	30
	100-249	4	5	7	27	5	6	12	10	22
	250-499	5	6	7	12	6	9	14	12	16
	500 and Over	5	6	7	14	6	11	13	10	23
	Total	3	3	4	8	3	6	7	7	13
Employment Size^f										
	Under 50	16	21	27	0	23	35	0	Q	0
	50-99	23	17	39	Q	17	19	Q	31	Q
	100-249	6	8	8	31	7	14	13	11	31
	250-499	5	6	7	14	6	9	12	13	17
	500-999	4	5	6	27	5	9	12	13	23
	1,000 and Over	4	5	6	11	6	11	11	14	19
	Total	3	3	4	8	3	6	7	7	13

^a "Alternative types of energy" consist of those that could have been substituted for residual fuel oil during 1988. The quantities are expressed as the percent of residual fuel oil that could have been displaced by the given alternative type of energy.

^b The estimates of total consumption include those quantities that were ascertained switchable or not switchable, plus an additional quantity for which the switching status was not ascertained.

^c "Electricity Receipts" represents those quantities of electricity generated off the manufacturing establishment site and available at the site for consumption. It includes those quantities for which payment was made, quantities transferred in, quantities purchased and paid for by a central purchasing entity, and quantities for which payment was made in kind. It does not include electricity generated onsite. "Electricity Receipts" has not been adjusted to account for any quantities that might have been resold or transferred out. The estimates include those quantities that were ascertained switchable or not switchable, plus an additional quantity for which the switching status was not ascertained.

^d "Other" includes all other types of energy not already identified that respondents indicated could have been consumed in place of residual fuel oil.

^e See Appendices A and E for descriptions of the Standard Industrial Classification system.

^f Value of Shipments and Employment Size were supplied by the Bureau of the Census. See Appendix A.

W=Withheld to avoid disclosing data for individual establishments. Data are included in higher level totals.

Q=Withheld because Relative Standard Error is greater than 50 percent. Data are included in higher level totals.

Source: Energy Information Administration, Office of Energy Markets and End Use, Energy End Use Division, Form EIA-846, "1988 Manufacturing Energy Consumption Survey."

**Table 20. Relative Standard Errors for Table 6
(Percent)**

Selected Characteristics		Coal and Coke			Alternative Types of Energy ^a					
		Total Consumed ^b	Switchable	Not Switchable	Electricity Receipts ^c	Natural Gas	Distillate Fuel Oil	Residual Fuel Oil	LPG	Other ^d
SIC Code^e	Industry Groups and Industry									
20	Food and Kindred Products	W	W	14	47	12	14	14	28	46
21	Tobacco Products	14	W	W	0	38	W	13	0	0
22	Textile Mill Products	9	11	13	W	14	19	11	25	37
23	Apparel and Other Textile Products	44	47	Q	Q	Q	Q	Q	Q	0
24	Lumber and Wood Products	42	0	42	0	0	0	0	0	0
25	Furniture and Fixtures	26	37	22	*	43	42	32	43	36
26	Paper and Allied Products	4	4	5	9	5	7	6	20	11
2621	Paper Mills	4	5	5	10	6	7	6	W	12
2631	Paperboard Mills	7	8	11	W	11	16	9	30	23
27	Printing and Publishing	0	0	0	0	0	0	0	0	0
28	Chemicals and Allied Products	6	8	8	13	11	11	9	35	W
2819	Industrial Inorganic Chemicals, nec	W	W	14	0	22	W	W	0	0
2821	Plastics Materials and Resins	11	13	12	0	16	W	16	W	0
2869	Industrial Organic Chemicals, nec	15	18	21	W	19	23	0	W	0
2873	Nitrogenous Fertilizers	0	0	0	0	0	0	0	0	0
29	Petroleum and Coal Products	10	12	16	W	14	12	14	27	W
2911	Petroleum Refining	10	12	16	W	W	W	14	W	W
30	Rubber and Misc. Plastics Products	14	20	17	0	20	33	W	0	0
31	Leather and Leather Products	50	Q	Q	0	Q	0	0	Q	Q
32	Stone, Clay and Glass Products	6	6	10	W	7	9	10	W	17
3241	Cement, Hydraulic	6	5	9	W	6	7	9	W	12
33	Primary Metal Industries	5	14	6	33	14	30	14	W	W
3312	Blast Furnaces and Steel Mills	6	15	6	W	15	14	14	W	W
3334	Primary Aluminum	0	0	0	0	0	0	0	0	0
34	Fabricated Metal Products	11	22	13	W	21	33	27	0	W
35	Industrial Machinery and Equipment	14	17	17	Q	18	20	29	41	Q
36	Electronic and Other Electric Equipment	16	20	18	0	20	37	34	0	34
37	Transportation Equipment	W	12	W	W	12	13	16	18	0
38	Instruments and Related Products	39	39	39	W	0	W	W	0	0
39	Misc. Manufacturing Industries	38	39	48	0	40	0	44	36	0
	Total	3	3	4	11	4	5	4	14	10
Census Region										
	Northeast	7	14	8	23	10	14	16	17	W
	Midwest	4	6	5	46	7	7	9	13	21
	South	W	W	6	9	5	6	5	22	0
	West	W	W	10	17	8	17	15	0	W
	Total	3	3	4	11	4	5	4	14	10
Value of Shipments^f (million dollars)										
	Under 20	12	12	18	22	13	22	29	23	W
	20-49	6	6	9	*	7	9	10	20	15
	50-99	5	7	6	29	9	8	9	Q	28
	100-249	4	6	5	14	8	7	6	17	13
	250-499	6	6	7	26	8	9	7	18	13
	500 and Over	5	8	5	15	9	14	10	27	W
	Total	3	3	4	11	4	5	4	14	10
Employment Size^f										
	Under 50	33	Q	46	Q	Q	Q	Q	Q	0
	50-99	17	14	23	0	15	16	21	28	0
	100-249	4	5	6	27	6	7	8	24	12
	250-499	8	6	10	30	8	8	8	15	W
	500-999	5	8	6	16	11	9	8	15	25
	1,000 and Over	4	5	5	10	6	10	7	24	12
	Total	3	3	4	11	4	5	4	14	10

^a "Alternative types of energy" consist of those that could have been substituted for coal and coke during 1988. The quantities are expressed as the percent of coal and coke that could have been displaced by the given alternative type of energy.

^b The estimates of total consumption include those quantities that were ascertained switchable or not switchable, plus an additional quantity for which the switching status was not ascertained.

^c "Electricity Receipts" represents those quantities of electricity generated off the manufacturing establishment site and available at the site for consumption. It includes those quantities for which payment was made, quantities transferred in, quantities purchased and paid for by a central purchasing entity, and quantities for which payment was made in kind. It does not include electricity generated onsite. "Electricity Receipts" has not been adjusted to account for any quantities that might have been resold or transferred out. The estimates include those quantities that were ascertained switchable or not switchable, plus an additional quantity for which the switching status was not ascertained.

^d "Other" includes all other types of energy not already identified that respondents indicated could have been consumed in place of coal and coke.

^e See Appendices A and E for descriptions of the Standard Industrial Classification system.

^f Value of Shipments and Employment Size were supplied by the Bureau of the Census. See Appendix A.

*=Estimate less than 0.5 rounded to zero.

W=Withheld to avoid disclosing data for individual establishments. Data are included in higher level totals.

Q=Withheld because Relative Standard Error is greater than 50 percent. Data are included in higher level totals.

Source: Energy Information Administration, Office of Energy Markets and End Use, Energy End Use Division, Form EIA-846, "1988 Manufacturing Energy Consumption Survey."

**Table 21. Relative Standard Errors for Table 7
(Percent)**

Selected Characteristics		LPG			Alternative Types of Energy ^a					
		Total Consumed ^b	Switchable	Not Switchable	Electricity Receipts ^c	Natural Gas	Distillate Fuel Oil	Residual Fuel Oil	Coal and Coke	Other ^d
SIC Code^e	Industry Groups and Industry									
20	Food and Kindred Products	W	27	Q	*	30	49	*	*	*
21	Tobacco Products	15	*	16	0	0	0	0	0	*
22	Textile Mill Products	12	13	16	*	14	*	31	0	*
23	Apparel and Other Textile Products	37	Q	43	Q	Q	*	0	0	*
24	Lumber and Wood Products	16	32	20	*	42	47	Q	0	Q
25	Furniture and Fixtures	19	39	22	*	44	*	*	0	*
26	Paper and Allied Products	8	12	9	33	24	15	*	*	*
2621	Paper Mills	7	14	7	*	16	W	0	0	*
2631	Paperboard Mills	8	18	8	*	19	0	*	0	*
27	Printing and Publishing	23	Q	26	*	Q	*	0	0	Q
28	Chemicals and Allied Products	11	11	15	*	11	26	17	0	21
2819	Industrial Inorganic Chemicals, nec	15	20	25	*	21	36	*	0	*
2821	Plastics Materials and Resins	13	16	22	*	16	*	*	0	*
2869	Industrial Organic Chemicals, nec	14	19	22	*	19	*	*	0	*
2873	Nitrogenous Fertilizers	*	0	*	0	0	0	0	0	0
29	Petroleum and Coal Products	7	7	11	20	8	11	8	26	20
2911	Petroleum Refining	7	7	11	15	8	W	8	W	20
30	Rubber and Misc. Plastics Products	W	18	18	*	24	27	*	0	*
31	Leather and Leather Products	25	*	23	*	*	*	0	0	*
32	Stone, Clay and Glass Products	10	14	15	15	15	18	14	0	43
3241	Cement, Hydraulic	*	*	*	*	*	*	0	0	*
33	Primary Metal Industries	12	11	20	27	12	24	*	*	23
3312	Blast Furnaces and Steel Mills	14	W	W	0	W	*	0	0	*
3334	Primary Aluminum	8	*	9	0	*	*	*	0	0
34	Fabricated Metal Products	12	20	14	35	21	46	*	*	31
35	Industrial Machinery and Equipment	15	26	20	*	33	39	*	0	Q
36	Electronic and Other Electric Equipment	31	Q	20	47	Q	*	*	*	*
37	Transportation Equipment	13	12	17	*	12	*	*	*	*
38	Instruments and Related Products	Q	Q	30	*	*	Q	0	0	*
39	Misc. Manufacturing Industries	39	33	23	*	*	*	0	*	*
	Total	5	6	7	15	6	9	8	25	15
Census Region										
	Northeast	W	W	10	47	12	12	25	*	20
	Midwest	W	W	22	24	8	16	11	W	26
	South	7	12	9	16	13	12	12	*	14
	West	9	10	13	21	11	15	12	W	26
	Total	5	6	7	15	6	9	8	25	15
Value of Shipments^f (million dollars)										
	Under 20	15	20	23	44	24	32	Q	Q	27
	20-49	8	17	10	15	20	39	25	0	27
	50-99	7	10	10	22	12	12	17	*	44
	100-249	6	9	8	26	10	17	24	*	16
	250-499	10	11	11	22	12	18	13	*	17
	500 and Over	8	9	12	16	9	12	10	W	22
	Total	5	6	7	15	6	9	8	25	15
Employment Size^g										
	Under 50	23	28	30	Q	32	49	Q	Q	44
	50-99	11	15	15	46	16	26	50	*	39
	100-249	8	11	9	35	12	16	14	*	38
	250-499	6	9	10	15	9	14	12	W	18
	500-999	7	8	12	25	8	12	W	*	23
	1,000 and Over	11	15	11	22	15	22	W	*	23
	Total	5	6	7	15	6	9	8	25	15

^a "Alternative types of energy" consist of those that could have been substituted for LPG during 1988. The quantities are expressed as the percent of LPG that could have been displaced by the given alternative type of energy.

^b The estimates of total consumption include those quantities that were ascertained switchable or not switchable, plus an additional quantity for which the switching status was not ascertained.

^c "Electricity Receipts" represents those quantities of electricity generated off the manufacturing establishment site and available at the site for consumption. It includes those quantities for which payment was made, quantities transferred in, quantities purchased and paid for by a central purchasing entity, and quantities for which payment was made in kind. It does not include electricity generated onsite. "Electricity Receipts" has not been adjusted to account for any quantities that might have been resold or transferred out. The estimates include those quantities that were ascertained switchable or not switchable, plus an additional quantity for which the switching status was not ascertained.

^d "Other" includes all other types of energy not already identified that respondents indicated could have been consumed in place of LPG.

^e See Appendices A and E for descriptions of the Standard Industrial Classification system.

^f Value of Shipments and Employment Size were supplied by the Bureau of the Census. See Appendix A.

^g * = Estimate less than 0.5 rounded to zero.

W = Withheld to avoid disclosing data for individual establishments. Data are included in higher level totals.

Q = Withheld because Relative Standard Error is greater than 50 percent. Data are included in higher level totals.

Source: Energy Information Administration, Office of Energy Markets and End Use, Energy End Use Division, Form EIA-846, "1988 Manufacturing Energy Consumption Survey."

**Table 22. Relative Standard Errors for Table 8
(Percent)**

Type of Energy and Minimum Leadtime to Switch ^b	Quantity Switchable ^a				
	Total United States	Census Region			
		Northeast	Midwest	South	West
Electricity Receipts^c (million kilowatthours)					
Less than one day	6	14	9	9	12
One day through one week	10	14	17	8	38
More than one week but within 30 days	14	40	17	23	44
Leadtime not ascertained	26	Q	45	30	36
Total	5	16	8	8	17
Natural Gas (billion cubic feet)					
Less than one day	2	5	4	4	5
One day through one week	3	7	4	6	6
More than one week but within 30 days	4	7	6	6	9
Leadtime not ascertained	5	10	9	7	12
Total	2	4	3	3	4
Distillate Fuel Oil (thousand barrels)					
Less than one day	8	11	11	15	12
One day through one week	14	21	27	28	18
More than one week but within 30 days	21	22	48	32	46
Leadtime not ascertained	13	23	27	16	38
Total	8	10	26	12	17
Residual Fuel Oil (thousand barrels)					
Less than one day	3	7	7	5	7
One day through one week	6	9	13	9	10
More than one week but within 30 days	11	14	14	10	Q
Leadtime not ascertained	27	17	20	Q	42
Total	3	5	6	4	6
Coal and Coke (thousand short tons)					
Less than one day	4	10	7	5	10
One day through one week	6	28	12	6	20
More than one week but within 30 days	7	33	10	W	W
Leadtime not ascertained	14	Q	22	18	Q
Total	3	14	6	W	W
LPG (million gallons)					
Less than one day	8	13	9	7	14
One day through one week	9	W	W	19	12
More than one week but within 30 days	15	23	17	Q	20
Leadtime not ascertained	15	25	37	24	27
Total	6	W	W	12	19

^a A specific type of energy may be switchable if the combustors had the necessary machinery or equipment in place so that the substitution could have been introduced within 30 days, while holding output constant, and without extensive modifications to the combustor. See Appendix A for more details. The estimates of quantities switchable represent the total consumption during 1988 that could have been replaced by an alternative fuel within the standard leadtime. These amounts can also be interpreted as the amount of 1988 consumption that could have been avoided if all possible switching within the leadtime had taken place.

^b "Time to switch" represents the minimum leadtime required to convert to a primary replacement type of energy in place of the indicated type of energy.

^c "Electricity Receipts" represents those quantities of electricity generated off the manufacturing establishment site and available at the site for consumption. It includes those quantities for which payment was made, quantities transferred in, quantities purchased and paid for by a central purchasing entity, and quantities for which payment was made in kind. It does not include electricity generated onsite. "Electricity Receipts" has not been adjusted to account for any quantities that might have been resold or transferred out. The estimates include those quantities that were ascertained switchable or not switchable, plus an additional quantity for which the switching status was not ascertained.

W=Withheld to avoid disclosing data for individual establishments. Data are included in higher level totals.

Q=Withheld because Relative Standard Error is greater than 50 percent. Data are included in higher level totals.

Source: Energy Information Administration, Office of Energy Markets and End Use, Energy End Use Division, Form EIA-846, "1988 Manufacturing Energy Consumption Survey."

**Table 23. Relative Standard Errors for Table 9
(Percent)**

Type of Energy and Minimum Leadtime to Switch ^a	Total United States	Census Region			
		Northeast	Midwest	South	West
From Natural Gas (billion cubic feet)					
Less than one day	9	21	43	11	17
One day through one week	14	23	17	21	39
More than one week but within 30 days	10	19	16	19	28
Leadtime not ascertained	30	Q	33	Q	Q
Total	6	12	14	9	15
From Distillate Fuel Oil (thousand barrels)					
Less than one day	27	19	29	37	Q
One day through one week	Q	Q	Q	32	0
More than one week but within 30 days	28	46	Q	41	0
Leadtime not ascertained	49	Q	25	*	0
Total	19	33	32	34	Q
From Residual Fuel Oil (thousand barrels)					
Less than one day	10	W	W	14	23
One day through one week	20	27	Q	33	44
More than one week but within 30 days	27	Q	Q	31	0
Leadtime not ascertained	31	35	0	35	0
Total	8	12	38	12	21
From Coal and Coke (thousand short tons)					
Less than one day	13	34	Q	W	W
One day through one week	11	20	26	W	W
More than one week but within 30 days	29	38	38	Q	0
Leadtime not ascertained	0	0	0	0	0
Total	11	23	46	9	17
From LPG (million gallons)					
Less than one day	15	*	W	W	W
One day through one week	Q	*	Q	*	W
More than one week but within 30 days	27	Q	24	W	30
Leadtime not ascertained	45	*	Q	*	*
Total	15	47	24	16	21

^a "Time to Switch" represents the minimum leadtime required to convert to a primary replacement type of energy in place of the indicated type of energy.

*=Estimate less than 0.5 rounded to zero.

W=Withheld to avoid disclosing data for individual establishments. Data are included in higher level totals.

Q=Withheld because Relative Standard Error is greater than 50 percent. Data are included in higher level totals.

Source: Energy Information Administration, Office of Energy Markets and End Use, Energy End Use Division, Form EIA-846, "1988 Manufacturing Energy Consumption Survey."

**Table 24. Relative Standard Errors for Table 10
(Percent)**

Type of Energy and Minimum Leadtime to Switch ^a	Total United States	Census Region			
		Northeast	Midwest	South	West
From Electricity Receipts^b (million kilowatthours)					
Less than one day	6	W	10	10	W
One day through one week	15	W	28	8	W
More than one week but within 30 days	16	44	19	31	46
Leadtime not ascertained	42	Q	Q	34	Q
Total	6	23	9	9	16
From Distillate Fuel Oil (thousand barrels)					
Less than one day	8	13	13	17	14
One day through one week	17	23	30	31	27
More than one week but within 30 days	24	24	Q	46	28
Leadtime not ascertained	13	22	29	17	39
Total	7	10	21	14	12
From Residual Fuel Oil (thousand barrels)					
Less than one day	4	7	8	5	7
One day through one week	7	10	16	11	12
More than one week but within 30 days	8	15	16	11	26
Leadtime not ascertained	26	17	18	Q	16
Total	3	6	7	4	6
From Coal and Coke (thousand short tons)					
Less than one day	5	11	8	6	11
One day through one week	8	W	13	8	W
More than one week but within 30 days	8	Q	11	14	W
Leadtime not ascertained	13	Q	20	17	Q
Total	4	10	7	5	6
From LPG (million gallons)					
Less than one day	8	16	9	7	15
One day through one week	10	17	34	21	13
More than one week but within 30 days	19	28	24	Q	26
Leadtime not ascertained	16	22	30	29	27
Total	6	12	8	13	11

^a "Time to Switch" represents the minimum leadtime required to convert to a primary replacement type of energy in place of the indicated type of energy.

^b "Electricity Receipts" represents those quantities of electricity generated off the manufacturing establishment site and available at the site for consumption. It includes those quantities for which payment was made, quantities transferred in, quantities purchased and paid for by a central purchasing entity, and quantities for which payment was made in kind. It does not include electricity generated onsite. "Electricity Receipts" has not been adjusted to account for any quantities that might have been resold or transferred out. The estimates include those quantities that were ascertained switchable or not switchable, plus an additional quantity for which the switching status was not ascertained.

W=Withheld to avoid disclosing data for individual establishments. Data are included in higher level totals.

Q=Withheld because Relative Standard Error is greater than 50 percent. Data are included in higher level totals.

Source: Energy Information Administration, Office of Energy Markets and End Use, Energy End Use Division, Form EIA-846, "1988 Manufacturing Energy Consumption Survey."

Table 25. Relative Standard Errors for Table 11 (Percent)

Type of Energy and Minimum Leadtime to Switch ^a	Total United States	Census Region			
		Northeast	Midwest	South	West
From Electricity Receipts^b (million kilowatthours)					
Less than one day	13	46	13	24	17
One day through one week	15	15	33	16	39
More than one week but within 30 days	18	39	20	33	50
Leadtime not ascertained	38	Q	48	Q	*
Total	10	23	13	18	25
From Natural Gas (billion cubic feet)					
Less than one day	3	9	5	5	8
One day through one week	5	10	6	8	8
More than one week but within 30 days	4	8	7	7	11
Leadtime not ascertained	6	14	11	10	16
Total	2	6	4	4	5
From Residual Fuel Oil (thousand barrels)					
Less than one day	9	17	15	18	16
One day through one week	8	13	30	11	15
More than one week but within 30 days	10	13	20	11	44
Leadtime not ascertained	39	34	28	Q	27
Total	6	8	14	8	16
From Coal and Coke (thousand short tons)					
Less than one day	5	W	8	9	W
One day through one week	8	W	W	12	W
More than one week but within 30 days	9	18	21	11	19
Leadtime not ascertained	20	Q	W	28	0
Total	5	14	7	6	17
From LPG (million gallons)					
Less than one day	15	19	29	16	22
One day through one week	18	41	28	34	23
More than one week but within 30 days	9	18	17	15	17
Leadtime not ascertained	32	*	Q	38	*
Total	9	12	16	12	15

^a "Time to Switch" represents the minimum leadtime required to convert to a primary replacement type of energy in place of the indicated type of energy.

^b "Electricity Receipts" represents those quantities of electricity generated off the manufacturing establishment site and available at the site for consumption. It includes those quantities for which payment was made, quantities transferred in, quantities purchased and paid for by a central purchasing entity, and quantities for which payment was made in kind. It does not include electricity generated onsite. "Electricity Receipts" has not been adjusted to account for any quantities that might have been resold or transferred out. The estimates include those quantities that were ascertained switchable or not switchable, plus an additional quantity for which the switching status was not ascertained.

*=Estimate less than 0.5 rounded to zero.

W=Withheld to avoid disclosing data for individual establishments. Data are included in higher level totals.

Q=Withheld because Relative Standard Error is greater than 50 percent. Data are included in higher level totals.

Source: Energy Information Administration, Office of Energy Markets and End Use, Energy End Use Division, Form EIA-846, "1988 Manufacturing Energy Consumption Survey."

**Table 26. Relative Standard Errors for Table 12
(Percent)**

Type of Energy and Minimum Leadtime to Switch ^a	Total United States	Census Region			
		Northeast	Midwest	South	West
From Electricity Receipts^b (million kilowatthours)					
Less than one day	9	15	16	19	11
One day through one week	9	W	15	10	W
More than one week but within 30 days	16	W	19	26	W
Leadtime not ascertained	50	Q	Q	Q	Q
Total	7	14	10	13	17
From Natural Gas (billion cubic feet)					
Less than one day	3	7	5	5	6
One day through one week	4	9	6	7	9
More than one week but within 30 days	5	13	8	8	12
Leadtime not ascertained	7	15	13	12	18
Total	2	5	4	4	5
From Distillate Fuel Oil (thousand barrels)					
Less than one day	15	32	Q	28	20
One day through one week	30	26	W	47	W
More than one week but within 30 days	29	28	Q	24	W
Leadtime not ascertained	31	40	42	32	*
Total	20	21	Q	20	16
From Coal and Coke (thousand short tons)					
Less than one day	6	W	13	7	W
One day through one week	7	27	13	7	29
More than one week but within 30 days	10	W	20	11	W
Leadtime not ascertained	14	Q	21	16	0
Total	4	16	9	5	15
From LPG (million gallons)					
Less than one day	10	*	13	18	13
One day through one week	16	0	19	W	W
More than one week but within 30 days	15	28	23	W	W
Leadtime not ascertained	*	0	0	*	*
Total	8	25	11	12	12

^a "Time to Switch" represents the minimum leadtime required to convert to a primary replacement type of energy in place of the indicated type of energy.

^b "Electricity Receipts" represents those quantities of electricity generated off the manufacturing establishment site and available at the site for consumption. It includes those quantities for which payment was made, quantities transferred in, quantities purchased and paid for by a central purchasing entity, and quantities for which payment was made in kind. It does not include electricity generated onsite. "Electricity Receipts" has not been adjusted to account for any quantities that might have been resold or transferred out. The estimates include those quantities that were ascertained switchable or not switchable, plus an additional quantity for which the switching status was not ascertained.

*=Estimate less than 0.5 rounded to zero.

W=Withheld to avoid disclosing data for individual establishments. Data are included in higher level totals.

Q=Withheld because Relative Standard Error is greater than 50 percent. Data are included in higher level totals.

Source: Energy Information Administration, Office of Energy Markets and End Use, Energy End Use Division, Form EIA-846, "1988 Manufacturing Energy Consumption Survey."

**Table 27. Relative Standard Errors for Table 13
(Percent)**

Type of Energy and Minimum Leadtime to Switch ^a	Total United States	Census Region			
		Northeast	Midwest	South	West
From Electricity Receipts^b (million kilowatthours)					
Less than one day	10	25	19	W	W
One day through one week	18	W	W	12	0
More than one week but within 30 days	36	Q	Q	45	Q
Leadtime not ascertained	W	0	0	W	0
Total	11	W	25	12	W
From Natural Gas (billion cubic feet)					
Less than one day	6	17	8	9	16
One day through one week	10	Q	13	15	W
More than one week but within 30 days	9	W	14	12	W
Leadtime not ascertained	18	27	19	36	*
Total	5	14	7	8	12
From Distillate Fuel Oil (thousand barrels)					
Less than one day	16	Q	26	22	25
One day through one week	Q	0	Q	*	0
More than one week but within 30 days	32	Q	Q	43	Q
Leadtime not ascertained	Q	Q	W	26	0
Total	15	37	26	27	24
From Residual Fuel Oil (thousand barrels)					
Less than one day	8	19	17	11	16
One day through one week	13	W	W	13	W
More than one week but within 30 days	16	W	W	37	0
Leadtime not ascertained	Q	Q	47	48	0
Total	7	14	18	8	15
From LPG (million gallons)					
Less than one day	W	0	W	*	W
One day through one week	Q	*	Q	0	0
More than one week but within 30 days	*	*	*	*	0
Leadtime not ascertained	*	0	0	0	*
Total	25	*	W	*	W

^a "Time to Switch" represents the minimum leadtime required to convert to a primary replacement type of energy in place of the indicated type of energy.

^b "Electricity Receipts" represents those quantities of electricity generated off the manufacturing establishment site and available at the site for consumption. It includes those quantities for which payment was made, quantities transferred in, quantities purchased and paid for by a central purchasing entity, and quantities for which payment was made in kind. It does not include electricity generated onsite. "Electricity Receipts" has not been adjusted to account for any quantities that might have been resold or transferred out. The estimates include those quantities that were ascertained switchable or not switchable, plus an additional quantity for which the switching status was not ascertained.

*=Estimate less than 0.5 rounded to zero.

W=Withheld to avoid disclosing data for individual establishments. Data are included in higher level totals.

Q=Withheld because Relative Standard Error is greater than 50 percent. Data are included in higher level totals.

Source: Energy Information Administration, Office of Energy Markets and End Use, Energy End Use Division, Form EIA-846, "1988 Manufacturing Energy Consumption Survey."

**Table 28. Relative Standard Errors for Table 14
(Percent)**

Type of Energy and Minimum Leadtime to Switch ^a	Total United States	Census Region			
		Northeast	Midwest	South	West
From Electricity Receipts^b (million kilowatthours)					
Less than one day	10	W	W	16	14
One day through one week	11	W	W	13	16
More than one week but within 30 days	23	Q	W	46	34
Leadtime not ascertained	47	Q	Q	40	0
Total	12	28	18	28	14
From Natural Gas (billion cubic feet)					
Less than one day	4	10	5	7	8
One day through one week	7	13	8	9	11
More than one week but within 30 days	5	12	8	7	11
Leadtime not ascertained	7	19	14	12	13
Total	3	6	4	5	6
From Distillate Fuel Oil (thousand barrels)					
Less than one day	14	18	21	23	29
One day through one week	16	30	W	30	W
More than one week but within 30 days	31	26	Q	35	W
Leadtime not ascertained	27	45	Q	39	50
Total	20	20	Q	26	15
From Residual Fuel Oil (thousand barrels)					
Less than one day	9	19	14	21	13
One day through one week	12	W	19	19	W
More than one week but within 30 days	10	W	18	17	W
Leadtime not ascertained	Q	0	0	Q	0
Total	7	13	11	12	9
From Coal and Coke (thousand short tons)					
Less than one day	18	0	W	W	0
One day through one week	20	W	W	W	0
More than one week but within 30 days	20	17	16	30	0
Leadtime not ascertained	22	Q	W	0	0
Total	14	17	13	22	0

^a "Time to Switch" represents the minimum leadtime required to convert to a primary replacement type of energy in place of the indicated type of energy.

^b "Electricity Receipts" represents those quantities of electricity generated off the manufacturing establishment site and available at the site for consumption. It includes those quantities for which payment was made, quantities transferred in, quantities purchased and paid for by a central purchasing entity, and quantities for which payment was made in kind. It does not include electricity generated onsite. "Electricity Receipts" has not been adjusted to account for any quantities that might have been resold or transferred out. The estimates include those quantities that were ascertained switchable or not switchable, plus an additional quantity for which the switching status was not ascertained.

W=Withheld to avoid disclosing data for individual establishments. Data are included in higher level totals.

Q=Withheld because Relative Standard Error is greater than 50 percent. Data are included in higher level totals.

Source: Energy Information Administration, Office of Energy Markets and End Use, Energy End Use Division, Form EIA-846, "1988 Manufacturing Energy Consumption Survey."

Appendix A

Survey Design, Implementation, and Estimates

Appendix A

Survey Design, Implementation, and Estimates

Introduction

The 1988 Manufacturing Energy Consumption Survey (MECS) has been designed by the Energy Information Administration (EIA) to provide information related to energy consumption in the manufacturing sector. It is the second such survey to be completed. The first survey collected data covering the year 1985. The MECS is an ongoing survey that is conducted every 3 years.

There were a few methodological and statistical refinements in the 1988 MECS. Most importantly, the 1988 data represent the entire manufacturing sector. This coverage is more complete than that of the 1985 MECS, which did not represent the smallest manufacturing establishments. Also, the 1988 MECS collected both consumption-related and fuel-switching data on the same data collection form. These were two separate collections on the 1985 MECS. Fuel switching refers to the capability of manufacturers to substitute alternative fuels for those actually consumed in 1988. The fuel-switching data are presented in this publication. The consumption-related estimates were presented in an earlier report.²⁹ Finally, the 1988 MECS sample was supplemented to account for new establishments (since the time of the 1985 survey), and to improve coverage of establishments that self-generated electricity.

The basic unit of data collection for this survey was the manufacturing establishment. A nationally representative sample of these establishments supplied the information through mailed questionnaires. The Industry Division of the Bureau of the Census selected the MECS sample according to EIA design specifications; conducted the fieldwork; and handled data processing, again with EIA input.

This appendix presents a summary of the design and implementation procedures for the survey and describes the types of estimates included in this report. Further details relating to the background of the survey, forms design, sample design, and estimation procedures can be found in the appendices to the consumption report. This appendix also presents a brief overview of these topics and describes the changes made for the 1988 survey.

Concept of Fuel-Switching Capability

EIA continues to employ the concept of fuel-switching that was developed prior to the 1985 survey. After extensive consultation with potential data users and data providers for the 1985 survey, EIA developed a tightly-specified concept of fuel-switching capability based on the following set of principles:

1. Switching data would cover consumption of energy for heat, power, and onsite electricity generation only. Switching of energy consumed as feedstock or raw material inputs would not be considered.
2. Switching data would focus on capability (what could be done) rather than actual performance (what was, or is being done) or future possibilities (what might be possible).
3. Switching capability would be collected for a closed historical reference period, rather than the present, or some future reference period.

²⁹Energy Information Administration, *Manufacturing Energy Consumption Survey: Consumption of Energy 1988*, DOE/EIA-0512(88) (Washington, DC, 1991).

4. Switching capability would be collected for the one-year reference period used for MECS consumption data, to tie in with the consumption data and avoid seasonal bias.
5. The survey would measure short-term response capability; that is, actions that could have taken place within 30 days of a decision to switch.
6. Switching capability would reflect the total flexibility provided by an establishment's equipment configuration. Both multiple-fired equipment and redundant or backup equipment could contribute to capability.
7. The survey would measure in-place capability; that is, capability provided by equipment that was already installed, or was available at the establishment for installation during the reference period. Major modifications to the design capabilities of equipment and major capital expenditures were not to be considered in assessing capability.
8. Switching capability would be valid only if, following the switch from one type of energy to another, the establishment would have been able to maintain its actual production schedule during the reference period.
9. Switching capability provided by an establishment's equipment configuration could be limited or negated by legal or practical constraints such as binding supply contracts, interruptible service, environmental regulations, or unavailability of supply or delivery systems for a potential alternative.
10. Economic considerations were *not* to be considered a practical constraint in evaluating switching capability. The survey was designed to measure potential response to changes in economics or supply patterns.

The MECS obtained fuel-switching data by asking respondents to determine the amounts of 1988 energy consumption of six major types of energy that could have been switched to one or more alternatives in accordance with the previously listed principles. The six types of energy were purchased electricity, natural gas, distillate oil, residual oil, coal and coke combined, and LPG. (For the 1985 survey, LPG was not one of the major energy sources for which fuel-switching data were required.) Respondents were directed to provide the quantities of switchable consumption by subtracting the quantities that were not switchable from the quantities that were actually consumed during 1988. Such an approach is clear and saves burden on the respondent because it permits subtracting those quantities known to be nonswitchable because of any one of the various conditions discussed above, rather than adding up those quantities for which all aspects of the concept are satisfied. Once the total switchable quantities had been determined, the remaining task was to determine how much of each switchable quantity could have been replaced by specific alternatives.

Description of the Manufacturing Sector

The manufacturing sector consists of all manufacturing establishments in the 50 States and the District of Columbia. The working definition of an establishment is the definition stated in the Office of Management and Budget's Standard Industrial Classification (SIC) Manual.

... an establishment is an economic unit, generally at a single physical location, where business is conducted or where services or industrial operations are performed...

Where distinct and separate economic activities are performed at a single physical location (such as construction activities operated out of the same physical location as a lumber yard), each activity should be treated as a separate establishment where: (1) no one industry description in the classification includes such combined activities; (2) the employment in each such economic activity is significant; and (3) separate reports can be prepared on the number

of employees, their wages and salaries, sales or receipts, and other types of establishment data.³⁰

In a later section, the SIC Manual describes the the types of operations engaged in by manufacturing establishments.

[Manufacturing establishments are] ... engaged in the mechanical or chemical transformation of materials or substances into new products. These establishments are usually described as plants, factories, or mills and characteristically use power driven machines and materials handling equipment. Establishments engaged in assembling component parts of manufactured products are also considered manufacturing if the new product is neither a structure nor other fixed improvement. Also included is the blending of materials such as lubricating oil, plastics, resins, or liquors.³¹

The SIC Manual contains a hierarchial classification system that groups establishments according to their primary economic activities. This system divides the manufacturing sector into 20 major industrial groups that are relatively homogeneous with respect to primary output. Each of these major industrial groups is assigned a two-digit code. The two-digit codes for the manufacturing sector range from SIC 20, Food and Kindred Products, through SIC 39, Miscellaneous Manufacturing Industries. Each major group is subdivided into three-digit groups which are further divided into four-digit industries. For example, SIC 20 includes SIC 201, Meat Products, which, in turn, is subdivided into SIC 2011, Meat Packing Plants; SIC 2012, Sausages and Other Prepared Meat Products; SIC 2016, Poultry Dressing Plants; and SIC 2017, Poultry and Egg Processing.

The SIC category is the single most important classification variable in the MECS data system, both for selecting the MECS sample and for analyzing the MECS data. The categories of primary interest for both the 1985 and 1988 MECS are the 20 major industrial groups (SICs 20 through 39) and the 10 most energy-consuming four-digit industries within these industry groups. A description of these 20 major industrial groups and 10 industries appears in Appendix E.

The 1988 MECS uses the SIC classification scheme presented in the 1987 edition of the manual. The 1985 MECS was based on the 1972 through 1977 SIC Manual. For the most part, the revisions were minor and had a negligible effect on the MECS estimates. However, there was one relatively significant revision in the way certain petrochemical plants were classified for the 1988 MECS as opposed to the 1985 MECS. If the primary product of a petrochemical plant in 1985 was a liquefied petroleum gas (LPG), e.g., ethane, propane, it was classified in SIC 2911, Petroleum Refining, regardless of how the LPG was produced. For the 1988 MECS, the establishment was classified in SIC 2911 only if the LPG was produced by a refinery process. If the LPG was produced by a chemical process, the establishment was classified in organic chemicals (SIC 2865 or 2869). Thus, when comparing the estimates for SIC's 2911, 2865, and 2869 between 1985 and 1988, the reader is cautioned to take the classification differences into account. A comparability study is currently being conducted to assess the effects of the changeover to the new edition. Results will be available in the fall of 1991.

The Sampling Frame and Its Relationship to the Manufacturing Sector

The 1988 MECS has expanded coverage over the 1985 MECS. The 1988 MECS estimates are for the *entire* manufacturing sector. The 1985 estimates excluded the smallest establishments from coverage. Therefore, caution must be exercised by readers who wish to compare 1985 with 1988 estimates. EIA estimates that the smallest establishments represent 2 to 3 percent of overall 1988 energy consumption. The percentage varies by industry group. In certain SIC's with many small establishments, such as Apparel (SIC 23) and Leather

³⁰Office of Management and Budget, *Standard Industrial Classification Manual*, 1987 (Washington, DC, 1987), p. 12.

³¹Office of Management and Budget, *Standard Industrial Classification Manual*, 1987, p. 67.

(SIC 31), the percentage difference is much larger. In SIC's dominated by large establishments, such as Chemicals (SIC 28) and Pulp and Paper (SIC 26), the coverage difference is negligible.

The 1988 MECS collected both consumption-related and fuel-switching data on the same questionnaire. Thus, no establishments were excluded beforehand from responding to the fuel-switching portion of the questionnaire as was the case in 1985.³²

As mentioned in the Introduction to this appendix, the Bureau of the Census serves as the collecting and compiling agent for the MECS. A major responsibility of the Industry Division of the Census Bureau is to conduct the Census of Manufactures (CM) and the Annual Survey of Manufactures (ASM). The CM is conducted for years ending in "2" or "7" (for example, 1982), and obtains economic data for the complete universe of approximately 350,000 manufacturing establishments in the United States. For the purpose of data collection, the CM universe is divided into two major subsets as follows:

1. **Small Single-Establishment Companies Not Sent a Report Form.** These companies are excused from filing a CM report. Generally, those with less than 5 employees are excused while all with more than 20 are mailed report forms. Those with 5 through 20 employees are excused or sent a report form based on the magnitude of their annual payroll and shipments data. Approximately 125,000 establishments are excused due to this criterion.
2. **Establishments Sent a Report Form.** The remaining manufacturing establishments in the universe are sent a report form.

The ASM is conducted during non-CM years to provide estimates of economic characteristics for the universe of manufacturing establishments. As with the CM, the ASM contains two components. The mail portion is a probability sample of manufacturing establishments selected from the list of establishments that are sent the CM report form (see above). Those establishments are weighted so that they represent the mail portion of the CM universe. The second component of the ASM is the nonmail portion of the CM. These small establishments are not sent an ASM questionnaire, but their contribution to economic statistics is estimated based on selected information obtained annually from other Federal agencies.

The approach to building a sampling frame for the 1988 MECS was to update the 1985 MECS frame for changes in the population since that time. This was accomplished by the following means:

- The 1987 Census of Manufactures (CM) mail file list was separated into two groups according to whether an establishment was in operation before 1984.³³
- The establishments in operation before 1984 were represented by 1985 MECS sample establishments that were still in operation when the MECS was mailed in 1989. This was done by retaining 1985 MECS sample establishments that were matched to the 1987 CM list. This group of establishments, called the holdover sample, retained the sampling weights based on their probabilities of selection for the 1985 MECS. (See "The Estimation Process" in this appendix.)
- A supplemental sample was drawn directly from those establishments on the 1987 CM list that came into existence after 1984. Together with the holdover sample, this supplement updated the sample to represent the 1987 CM mail file.

³²For the 1985 MECS fuel-switching supplemental questionnaire, MECS respondents to the consumption questionnaire were excluded if (a) they did not return their consumption report in time for the fuel-switching questionnaire, and (b) they reported only consumption of electricity. See Energy Information Administration, *Manufacturing Energy Consumption Survey: Fuel Switching 1985*, DOE/EIA-0515(85) (Washington, DC, 1988).

³³The year 1984 was used as a cutoff because establishments that began operation during that year were omitted from the 1985 MECS sample.

- The MECS sample results were then further modified to represent the entire manufacturing population (including the nonmail file of the CM) by an adjustment to the sampling weights. (See "The Estimation Process" section in this appendix.)

Sample Design

In order to maximize EIA's ability to estimate changes in consumption from 1985 to 1988, the 1988 MECS sample consisted of two major components. The first, comprising approximately 10,600 establishments, is a "holdover" component that included establishments in the 1985 MECS sample that were still in operation when the MECS was mailed on June 15, 1989.

For the 1985 survey, the overall desired size of the MECS sample was set at 12,000 establishments based upon available resources and preliminary estimates of expected and desired sampling error. The desired sample size was allocated among 30 industry-based strata consisting of the 10 most energy-consumptive four-digit SIC industries and the remaining portions of the 20 two-digit SIC industry groups. Due to random variability in the sample selection process, the actual sample contained 12,065 establishments. For the 10 most energy-consumptive industries, all the establishments in the 1984 ASM sample were included in the 1985 MECS sample with certainty. The remaining establishments were sampled from ASM sample cases in the 20 two-digit groups in a pattern designed to keep sampling errors within pre-established bounds for estimates of total consumption and consumption of four major types of energy: electricity, natural gas, residual oil, and coal. The procedure for subselecting ASM sample establishments into the MECS sample was such that their overall probabilities of selection for the MECS were proportional to an estimated energy measure of size. The overall probabilities for selection of the MECS sample establishments ranged from 0.002 to 1.000.

The selection of the MECS sample for 1985 was, therefore, a two-stage process, with the first stage being the selection of the ASM mail sample, and the second being the subselection of the MECS sample from the ASM sample. Thus, a MECS sample establishment was selected conditional upon its having been selected into the ASM mail sample, which means that its probability of selection from the ASM sample was a conditional probability. Therefore, the overall probability of selection into the 1985 MECS sample was represented by the product of this conditional probability and its ASM selection probability. The 1985 probability of selection was carried over as the basis for sampling weights attached to holdover establishments in the 1988 sample.

The second component of the 1988 MECS consisted of two supplemental samples. The first, comprising about 1,500 establishments, represented that part of the 1987 CM mail file not covered by the hold-over sample. Establishments beginning operation after 1984 were selected into the 1988 MECS using an energy measure of size that estimated 1987 purchased fuel consumption. The probabilities for selection into the MECS sample are proportional to an energy measure of size computed similarly to the 1984 measure. The measure of size is the ratio of average 1985 total Btu per cost of fuels within an establishment's sampling stratum and region, multiplied by the establishment's 1987 CM value for cost of fuels. If the new establishment was: (a) large enough to be mailed an ASM form in any year after 1984; and (b) was also classified in one the 10 four-digit industries previously found to be the most energy-consumptive, it entered the MECS with certainty. Otherwise, its entry would be as a result of the same random selection process used for the original selection of the 1985 MECS sample.

The second supplement comprised all establishments not otherwise selected for the 1988 MECS that reported onsite electricity generation of over 10,000 kWh on the 1987 CM. The purpose of this supplement was to produce the best possible estimates of onsite electricity generation and associated measures. The generation supplemental sample added approximately 300 establishments to the total MECS sample. (Because the fuel-switching data collection only dealt with electricity receipts, the electricity generator supplemental sample was not relevant to the data presented in this publication.)

The 1988 MECS sample thus consisted of approximately 12,400 establishments; the 10,600 establishments in the holdover sample, plus the 1,800 establishments in the two supplemental samples. Of the initial sample, approximately 200 were determined to be out of business or out of scope based on updating procedures used

by the Bureau of the Census. Thus, a final sample of 12,200 establishments were mailed a questionnaire. Of these, usable responses were received from 10,650 or 87 percent of those establishments. However, those respondents represented 96 percent of the total unweighted value of shipments and receipts of the final sample.

Fieldwork, Editing, and Quality Control

The 1988 MECS used customized questionnaires (see Appendix D) for specific industries, with similar energy consumption characteristics. The three questionnaires were:

- **Form EIA-846(A).** This questionnaire was sent to the majority of the sample and was used to collect the basic consumption, expenditure, and fuel-switching information.
- **Form EIA-846(B).** This questionnaire was sent exclusively to establishments in the petroleum refining industry (SIC 2911). The design of the questionnaire took advantage of the fact that other EIA surveys collect certain consumption and expenditure data from the refinery population. Thus, the EIA-846(B) did not require respondents to report on particular data items. The questionnaire also was used to collect data on nonfuel use and shipments of energy sources from adjoining petrochemical plants.
- **Form EIA-846(C).** This questionnaire was sent to establishments in the blast furnaces and steel mills industry (SIC 3312), producers of chemicals and allied products (SIC 28), and producers of petroleum and coal products other than petroleum refiners (SIC 29 excluding SIC 2911). It is identical to the EIA-846(A) except that the questionnaire was used to collect additional information on shipments of energy sources produced onsite.

The questionnaires were mailed to the inscope MECS sample establishments on June 15, 1989. Returned questionnaires were subjected to initial screening procedures for completeness. Forms that were incomplete or that contained responses with obvious inconsistencies were set aside for review by industry specialists. Valid returned questionnaires were forwarded directly to check-in and then to data entry.

All forms that failed the initial screening procedures were carefully reviewed by industry specialists from the Census Bureau and EIA. The specialists obtained missing data and verified questionable items by telephone contact with the individual who completed the questionnaire. Once the forms were completed and verified, they were forwarded to check-in and to data entry.

The resulting MECS data file was then subjected to a series of computer edits. These edits included consistency checks against data items from other parts of the MECS and the 1988 ASM, as well as checks for outliers in the distribution of individual variables. Records with failed edits were reviewed and followed up by industry specialists.

Development of the Data File

The estimates in this report were developed from a data file consisting of directly reported values and of more complex measures derived from a combination of directly-reported values. The data relevant to the fuel-switching tables are for the most part aggregates of directly-reported values. The one exception is Table 8, which summarizes minimum leadtime necessary to switch from various fuels. These data were formed by an iterative process described in the section titled "Survey Estimates".

Reported values for fuel consumption and fuel switching consist of responses to the 1988 MECS questionnaire. The responses to the questionnaire for each responding establishment were supplemented by the following economic data:

- Value of shipments and receipts

- Value added by manufacturing
- Total employment.

These economic data were not collected by the 1988 MECS, but were provided by the Census Bureau by linking the 1988 ASM economic data and MECS energy data at the establishment level.

The Estimation Process

Estimates in this report represent the entire population of manufacturers in the CM universe that were covered in the 1988 ASM. Full representation is accomplished by weighting the data from the establishment records in the consumption data file. Weighting is the process of multiplying the reported or derived values by a case-specific constant designed to inflate the data from each sample case to that portion of the population which it represents. The basic component in the MECS weights is the sampling weight. The sampling weight for a MECS sample case is the reciprocal of its overall probability of selection, first into the ASM and subsequently into the MECS.

The second component of the MECS weights is an adjustment for nonresponse. Adjustment factors to account for nonresponse were calculated by using the known energy measures of size of the respondents and the total sample. Because a MECS respondent is selected with probability proportional to its energy measure of size, that measure of size can be viewed as a measure of an establishment's estimated contribution to energy consumption in 1987. A separate adjustment factor was computed for each of the 30 sampling strata³⁴ and took the form:

$$a_s = \frac{\sum_j^{Sample} MOS_{s,j}}{\sum_i^{Resp} MOS_{s,i}}, \quad (1)$$

where $MOS_{s,j}$ is the measure of size for MECS sample establishment j in stratum s , and $MOS_{s,i}$ is the measure of size for MECS respondent i in stratum s . The sampling weight for each MECS respondent was multiplied by the adjustment factor the stratum to produce a nonresponse-adjusted weight.

The last adjustment to the weights took advantage of the fact that a recent enumeration of the population, the 1987 CM, was performed prior to the compilation of the MECS data. It is difficult to maintain the accuracy and currency of a sample over a number of years even employing the established updating methods used by the Census Bureau. Time restrictions and the desire to have a longitudinal component in the MECS precluded drawing a completely new sample. Therefore, the MECS sample data were further adjusted by using known CM totals.

The adjustment that was used is different from the one that is routinely employed for ASM data. In the ASM case, cell totals have high correlations from year to year as a result of including many of the same establishments for each ASM within a CM cycle. By taking advantage of those correlations, cell totals can be made more reliable. The adjustment the Census Bureau chose maximizes those benefits.³⁵ In that adjustment, CM data are substituted into the ASM sample establishments and a difference between that estimate and the actual Census total for any particular variable is computed. That difference is then added to the ASM data for the current year. The adjustment is shown in Equation (2):

³⁴For the 1985 MECS, there was a separate adjustment for employment size category as well as for sampling stratum. That added separation proved not to be worthwhile.

³⁵For a more detailed discussion, see U.S. Department of Commerce, Bureau of the Census, *The Annual Survey of Manufactures: A Report on Methodology*, Technical Paper No. 24, U.S. Government Printing Office (Washington, DC, February 1971).

$$Y'' = Y' - X' + X, \quad (2)$$

where Y'' is the adjusted ASM value, Y' is the ASM sample estimate for the current year, X' is the ASM sample estimate for the Census year, and X is the Census total for the Census year.

As all ASM quantities are also collected by the CM, the ASM coverage adjustment can be done in summation form, customized to individual ASM variables. In order to have the MECS sample represent the 1988 MECS population as closely as possible, analogous adjustments for the MECS data items would be desirable. However, most data items collected by the MECS are not included on the CM. Data items included in the MECS are related to energy consumption and fuel switching, while ASM and CM data items are economic in nature. Therefore, a simple difference for corresponding items cannot be used to adjust MECS data as was done for the ASM data. Rather, a single measure collected on both the CM and the MECS was used to ratio-adjust all the MECS data items. The measure chosen was cost of fuels as it has shown a high correlation with energy consumption in the past.³⁶

Each MECS nonresponse-adjusted weight was thus further adjusted by multiplying the weight by the ratio of cost of fuels as measured by the 1987 CM to the 1987 cost of fuels estimate based on CM reported data, but restricted to MECS respondents. This ratio was computed for each of the 30 MECS sampling strata (20 two-digit industry groups and 10 four-digit industries). The ratio adjustment to the MECS weights takes the following form:

$$R_s = \frac{\sum_j^{CM} (CF_{sj})}{\sum_i^{MECS} (NW_{si} CF_{si})}, \quad (3)$$

where R_s is the adjustment to the MECS nonresponse-adjusted weight in stratum s , CF_{sj} is the 1987 cost of fuels value for establishment j in stratum s from the 1987 CM, NW_{si} is the nonresponse-adjusted 1988 MECS weight for establishment i in stratum s , and CF_{si} is the 1987 cost of fuels value for 1988 MECS sample establishment i in stratum s . The final adjusted weight for MECS respondents is its nonresponse-adjusted weights multiplied by the appropriate value of R_s . That is,

$$W_{si} = R_s NW_{si}, \quad (4)$$

where W_{si} is the final adjusted MECS weight for establishment i in stratum s , R_s is the ratio adjustment based on cost of fuels for stratum s , and NW_{si} is the nonresponse-adjusted weight for establishment i in stratum s .

As was discussed in "The Sampling Frame and Its Relationship to the Manufacturing Sector," the adjustment of the sampling weights according to Equation (3) extends the MECS sample coverage to the entire manufacturing sector. This was not the case for 1985 when no CM-based ratio adjustment was performed.³⁷ The CM totals for cost of fuels includes the nonmail file imputed totals for cost of fuels as well as the mail file totals. Hence, by using the adjustment described in Equation (3), nonmail cases are also covered by the MECS.

³⁶Correlation coefficients between 1981 ASM establishment values of total purchased fuels and electric energy and the cost of fuels and electric energy ranged from .78 to .98 within two-digit SIC categories. (Unpublished document, U.S. Department of Commerce, Bureau of the Census.)

³⁷The 1985 and 1988 MECS samples were both based on the 1982 CM file, augmented with updates to represent subsequent population changes as well as possible. Because the elapsed time between the 1985 MECS and the 1982 CM was shorter, there was less coverage degradation in the first cycle. As the 1987 CM and the 1988 MECS covered the same population, the adjustment described in Equation (3) is a natural one. However, there were no corresponding Census data available to adjust the 1985 MECS.

For highly disaggregated estimates, the ratio adjustment is not as advantageous as for others. Indeed, as the same adjustment is used for all estimates within a stratum, it is possible that the adjustment could affect some estimates in an adverse way. This problem is discussed in greater detail in Appendix B.

Survey Estimates

All estimates of fuel-switching capability appearing in this report were calculated by multiplying the data collected from the sampled establishments by the final adjusted weights. Those weights establish the relationship between the responding establishments and the manufacturing sector as defined for the MECS.

Table 1 presents estimates of nonswitchable minimum requirements and the maximum consumption potential of the different types of energy covered specifically by the fuel-switching section of the MECS. An estimate of the actual consumption of each type of energy is provided as a reference point. That consumption estimate represents the quantity that was consumed onsite for the production of heat, power, and the generation of electricity in 1988. The estimates are identical to the ones found in Table 3 of the consumption report, except for estimates of electricity. For fuel-switching, the electricity quantity considered is electricity receipts found in Table 4 of the consumption report. (The reasons for using electricity receipts are explained in this section.)

One of the purposes of Table 1 is to provide an estimate of the smallest possible quantity of a given type of energy that would have been required in 1988 (keeping production constant), if all possible ascertained switching away from that type of energy had taken place. The quantities given in the minimum consumption column of Table 1 are likely to be higher than the true minimum energy requirements because they include the quantity of 1988 consumption for which switching capability was not ascertained. Some unknown proportion of this latter quantity could likely have been replaced.

Table 1 also provides estimates of the maximum energy consumption that would have been possible if all ascertained switching to that type of energy had occurred. The estimates assume that all indicated substitutions were simultaneously possible and the substitutable amount consists of the sum of all possible switches to the designated type of energy. An assumption of this kind is necessary because there is no specified limit to a respondent's ability to switch *into* an energy source. Note that there is a given limit to a respondent's ability to switch *out of* an energy source provided by the third row of the fuel-switching section of the MECS questionnaire (see Appendix D). For the 1985 MECS, Table 1 had both a "high" and "low" estimate for maximum energy consumption for an energy source. The high estimate employed the current assumption described. The "low" estimate assumed that when a type of energy was reported as an alternative for two or more other types of energy at an establishment, only a single substitution was possible at any one time. The substitutable amount consisted of the single, largest switchable amount from any type of energy to the designated energy type. Because the actual differences between the "high" and "low" estimates for maximum consumption in 1985 proved to be relatively small, EIA decided to present only the high estimate for the 1988 MECS.³⁸

Tables 2 through 7 present estimates of the capability of substituting specific alternative types of energy for those actually consumed, holding production constant. Each table contains information for the specific type of energy that was actually consumed for the production of heat, power, and generated electricity in 1988. It should be noted that the first column of Table 2 refers to "total receipts" of electricity, while the first column of Tables 3 through 7 refers to "total consumed" natural gas, distillate fuel oil, residual fuel oil, and coal and coke, respectively. Thus, the quantities of electricity generated onsite are excluded as are the quantities of

³⁸The "low" and "high" estimation techniques may be illustrated by an example. Assume a respondent reported that the total consumption of natural gas for 1985 was 15 million cubic feet, and that 2 million and 5 million cubic feet of natural gas could have been consumed as alternatives for residual fuel oil and coal, respectively. The "low" estimate of the maximum consumption of natural gas for that respondent would have been 20 million cubic feet, and the "high" estimate would have been 22 million cubic feet.

electricity leaving the establishment site.³⁹ When considering fuel-switching capabilities, total electricity receipts is a more meaningful quantity than total electricity consumption. A respondent who has onsite generation of electricity has, more than likely, used an additional amount of a combustible energy source to operate the generator. It is a valid question to ask, "how much of that self-generation is replaceable by electricity receipts?" However, it is more reasonable and of greater interest to collect the fuel-switching data for the fuel used to generate the electricity by asking respondents to show the quantity of electricity receipts that could replace the combustible fuel.

In Tables 2 through 7, the estimates provided in the columns labeled "alternative types of energy" should be read independently because respondents were instructed to enter the maximum amount of the quantity of the energy actually consumed, which could have been replaced by a given alternative. For example, Table 3 shows that for Paper and Allied Products (SIC 26), a total of 237 billion cubic feet of natural gas was ascertained switchable. Electricity receipts could have replaced 12 billion cubic feet of that quantity. The other replacement quantities are distillate fuel oil, 90 billion cubic feet; residual fuel oil, 151 billion cubic feet; coal and coke, 20 billion cubic feet; LPG, 12 billion cubic feet; and other, 3 billion cubic feet. Because each value represents the maximum quantity of natural gas that could have been replaced, their sum exceeds the total quantity of natural gas that was ascertained as switchable. This difference indicates that some establishments had more than one type of energy that could have been substituted for natural gas usage during 1988.

Table 8 presents estimates of the 1988 quantities of specific types of energy that could have been switched to an unspecified alternate energy type, categorized by the time required to make that switch. Each potential switch on the questionnaire had an associated leadtime.⁴⁰ The quantities in Table 8 represent the minimum leadtime for any possible switch out of an energy source. For cases in which a respondent had two or more possible alternatives that could substitute for the energy source under consideration, the fuel-switching capability was allocated in order of the descending leadtime to switch. For example, if a respondent indicated that the substitutable natural gas consumption could be switched into distillate fuel oil or LPG, the substitution that could be made within the shortest leadtime would be counted first. The remaining switchable natural gas consumption (if any) would be covered by the second alternative and assigned that leadtime. If there are more than two alternatives, the process is done iteratively in this fashion until the entire amount of switchable consumption is covered. This process ensures that the sum of the quantities of switchable fuel categorized by leadtime would exactly equal the total switchable consumption. (The total amount of switchable fuel is less than or equal to the sum of the quantities of replacement fuels). In addition, this process minimizes the overall leadtime of switching out of a fuel. It is based on the assumption that manufacturing establishments will make the most rapid substitution possible in a time of emergency.

Tables 9 through 14 present estimates of leadtimes to switch into the energy source under consideration from the major energy sources. The totals represent aggregations of specific cells on the fuel-switching section of the questionnaire. Each substitution is counted without regard to whether the substitution can be done simultaneously with another switch. This is *not* a problem as long as the totals are considered independently of each other. For example, if a respondent indicated that both coal and natural gas could be replaced by purchased electricity, both amounts would be counted in the Table 9 quantities under the appropriate fuel subtotals. It is conceivable, although not measurable by the current design of the questionnaire, that all or part of the switching from one of the fuels into electricity could not be accomplished if the switch from the other had occurred. In other words, the totals represent the amount of switching from one fuel into another if all other switching had no bearing on the outcome. This same assumption was used for developing the maximum consumption estimates in Table 1. Indeed, if the totals in Table 9 were converted to million

³⁹The quantity of electricity used for fuel switching in the 1988 MECS differs from the one used for the 1985 MECS. The 1985 MECS excluded transfers in as well as the other quantities mentioned leaving only purchased electricity. The fuel-switching information was gathered separately from the consumption data in the 1985 MECS. This situation necessitated pre-printing consumption data on the fuel-switching questionnaire before mailout. Hence, electricity purchases were chosen to facilitate a timely mailout and to present the respondent with an easily recognizable quantity.

⁴⁰In the 1985 MECS, leadtime data were collected only for the primary replacement fuel (i.e., the replacement fuel of greatest magnitude). For the nonprimary replacement fuels, leadtimes were not assigned. If two or more replacement fuels were of equal magnitude and no other replacements were larger, respondents were instructed to indicate the leadtime for the substitution that could have been made in the shortest time.

kilowatthours, summed together, and then added to the actual consumption of electricity receipts, the result would be the national level estimate of maximum consumption of electricity receipts found in Table 1.

The Heat Content of Energy

The estimates in the tables of this report are presented in physical units (kilowatthours, barrels, short tons). For comparative purposes, it may be desirable to convert these physical units to a common base. Conversion to British thermal units (Btu) provides such a base (see Table A1 below). A Btu is the quantity of heat required to raise the temperature of 1 pound of water by 1 degree Fahrenheit. Thus, converting physical units of a given type of energy to Btu is a means of expressing the heat content of that energy. All Btu quantities are in terms of higher heating value, with no regard for efficiency of use. Because no energy consumption process is 100 percent efficient (although some are considerably more efficient than others), Btu figures must be considered as the maximum available heat content. The following table presents the Btu conversion factors of major types of energy.

Table A1. Conversion of Physical Units to British Thermal Units

Type of Energy	British Thermal Units (thousands)
Electric Energy (1,000 kilowatthours)	3,412
Residual Fuel Oil (42 gallon barrels)	6,287
Distillate Fuel Oil (42 gallon barrels)	5,825
Natural Gas (1,000 cubic feet)	1,032
Liquefied Petroleum Gas (42 gallon barrels)	3,603
Coke and Breeze (short ton)	24,800
Coal Used as Fuel (short ton)	22,012
Coal Used for Coking (short ton)	26,800

Source: Energy Information Administration, *Monthly Energy Review*, (September 1990), pp. 124-127.

Appendix B

Quality of the Data

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Quality of the Data

Introduction

All data collection activities and the estimates produced from them are subject to a variety of errors. These errors may be broadly classified under two general types, sampling error and nonsampling error.

Sampling error is defined as the variability in a survey estimator that arises because data are collected from a sample of units rather than the entire population. Each possible sample produces different estimates of population parameters, depending on the set of respondents that are selected. Nonsampling errors, on the other hand, occur in any data collection activity, whether a sample survey or a complete census. Nonsampling errors are attributable to all aspects of the total survey design other than the sampling process, and can include both random and systematic (biasing) errors. Commonly recognized sources of nonsampling error include undercoverage, random and systematic response errors, nonresponse, data processing errors, and tabulation errors. This appendix describes the effect of both sampling and nonsampling errors on data from the MECS.⁴¹ More details are presented in the methodological report for the MECS.⁴¹

Sampling Error

The estimated values appearing in this report were developed from a sample of manufacturing establishments and, as a result, will differ from true population values that would be obtained from a complete census. This is because the MECS sample is only one of a very large number of samples that could have been selected under the same sampling specifications. Each possible sample would yield its own estimates of the true population values, with the differences attributable to the particular set of establishments selected into each sample.

One measure of variability due to sampling is the average difference between the estimates that would be produced by all possible samples and the mean value of these estimates. This type of measure is commonly known as sampling error. Estimates of the magnitude of these sampling errors based on data from a single sample are provided by a statistic known as the standard error of an estimate. Standard errors for MECS estimates are computed from the reported data using the formula:

$$s_y = \sqrt{\sum_{i=1}^n y_i^2 (W_i - 1)} \quad (5)$$

where $\hat{Y} = \sum(y_i W_i)$ is the MECS survey estimator, y_i is the reported value of characteristic Y for the i^{th} MECS sample case, W_i is the final adjusted weight used to inflate the sample data to population estimates, and n is the number of MECS respondents. Justification for this formula is found in the MECS methodological report.

Estimates of standard errors have been computed from the MECS sample data for the estimated aggregate values and ratios appearing in this report. They are presented in the form of relative standard errors (RSE); that is, the standard error divided by the estimated value to which it refers. The RSE's are given in Tables 15 through 28.

⁴¹Energy Information Administration, *Manufacturing Energy Consumption Survey: Methodological Report 1985*, DOE/EIA-0514(85) (Washington, DC, November 28, 1988). Although this report describes data quality in the 1985 MECS, much of the discussion still holds for the 1988 MECS.

The estimates in this report can be used to produce proportion statistics based on the ratio of various estimates reported in the tables. Proportions are not given in the detailed tables but can be used to clarify the analysis. A proportion is a statistic of the form

$$\hat{P} = \frac{\hat{Y}}{\hat{X}}, \quad (6)$$

where \hat{Y} and \hat{X} are survey-based estimates of aggregate parameters Y and X , respectively, and characteristic X "encompasses" characteristic Y . That is, each population element (and, thus, each sample case) that contributes to Y also contributes to X , and the value of X for each element is greater than or equal to the value of Y .

The RSE's of aggregate statistics shown in Tables 15 through 28 can be used to produce approximate errors for proportions. The straightforward additive error formula shown in Equation (5) gives rise to a similarly straightforward upper bound approximation to the error of an estimated proportion. The approximation can be expressed in terms of relative error as:

$$RSE(\hat{P}) \leq \sqrt{[RSE(\hat{Y})]^2 \cdot (1 - 2\hat{P}) + [RSE(\hat{X})]^2}. \quad (7)$$

Justification for this formula is found in the MECS methodological report.

Nonsampling Errors and Bias

Nonsampling errors that affect MECS survey data can be divided into four major categories:

- *Operational errors*, including editing, coding, and tabulation errors,
- *Errors of measurement*, including a lack of precision by the respondent, failure of the respondent to understand instructions, etc.,
- *Errors of estimation*, including the assumptions underlying the values for maximum consumption,
- *Errors of nonobservation*, including nonresponse and noncoverage.

These errors are collectively referred to as nonsampling errors because they are not related to the sampling process, and thus would be equally likely to occur in a complete census or a sample survey.

It is felt that operational errors are not a major concern for the estimates included in this report. The quality control procedures that were employed for check-in, editing, coding and keying the returned questionnaires (see Appendix A) are standard procedures that are in place at the Bureau of the Census and have withstood the test of time. Data tabulations were verified by comparing marginal totals in tables generated from files supplied to EIA with corresponding totals generated directly from microdata files held at the Bureau of the Census.

Errors of measurement are a concern in any data collection activity. The survey results for the MECS were subjected to extensive editing procedures that were specifically designed to detect errors of measurement. Failure of any of these tests for reasonableness and consistency resulted in the respondent being called by an analyst familiar with manufacturing processes and energy use. Major errors, including omissions and misreporting by orders of magnitude, were corrected. No editing procedure is capable of identifying all measurement errors, however, and some small errors will remain. To the extent that these errors are due to random, rather than systematic misjudgments, they are compensating in the aggregate totals presented in this report, and it is believed that there are few large systematic biases that result from them.

Errors of estimation could have resulted from the assumptions that underlie the formation of the maximum consumption estimates. Implicit in those estimates is the assumption that all potential switches at an establishment can be made simultaneously. For example, if a respondent indicated that natural gas could substitute for both distillate fuel oil and coal, the two quantities are summed together (after conversion to like units) to count toward maximum consumption of natural gas. To the extent that one or more substitutions are constrained by the performance of another, the published maximum consumption quantities would overestimate the "true" value.

An error of estimation might occur using the method employed in Table 8, which presents estimates of capability to switch from designated energy sources to unspecified replacement fuels. The allocation of total switching capability of an energy source to leadtime category is performed iteratively in order of descending speed of substitution. If a respondent has three or more possible replacements for a specified energy source, it is possible that the respondent would not be able to switch in order of fastest to slowest. For example, a respondent might indicate that 1,000 barrels of residual fuel oil could be switched to three replacement energy sources: natural gas, coal, and LPG. Each of the fuels could alone replace 800 barrels of the residual oil with natural gas switchable in less than a day, coal in three days, and LPG in three weeks. The method employed in Table 8 would allocate 800 barrels of switchable residual oil to the category "less than one day" and 200 to the category "one day through one week" (1000 minus 800). It is possible that if a switch to natural gas was made, due to the system of boilers in place at the establishment, LPG might be the only possible substitution available. That would mean that the 200 barrels would have been more appropriately allocated to the category "more than one week," and the Table 8 method would have misrepresented the true situation. The expectation is that this source of error should be minor. A respondent rarely reports more than two replacements for any one switchable energy source. Moreover, it is even more unlikely that each of the replacements would have a different leadtime associated with it.

Finally, several potential sources of nonsampling error and bias result from errors of nonobservation. As described in Appendix A, the 1988 MECS data were adjusted to cover the entire universe of manufacturers. Although this represents more complete coverage than the 1985 MECS, the additional coverage does not eliminate the need to make certain assumptions about the adjustments. For both the coverage and the nonresponse adjustments, the procedure was to ratio adjust the weighted data from the MECS respondents to the estimated totals for the universe that was targeted by the MECS frame and sample design. Clearly, had these adjustments not been performed, the estimates produced from only the responding establishments would not have been representative of the target universe for the MECS. Such estimates would have been biased. Adjusting the sampling weights to reflect the target universe is an attempt to mitigate the potential effects of such a bias.

As described in Appendix A, separate adjustment factors were developed for each sampling stratum. Nonresponse adjustment factors were calculated for each of the 30 sampling strata using estimated 1988 fuel consumption for heat and power as estimated by the total energy measure of size for each stratum. Each stratum represents a relatively homogeneous subgrouping of establishments with respect to primary product output and level of fuel consumption.

Implicit in that procedure is the assumption that primary product output and level of fuel consumption are highly correlated with energy consumption patterns, so that the establishments within a stratum would also be homogeneous with respect to the quantities, types, and shares of energy consumed as fuels and for nonfuel purposes. Also, the weight adjustment method assumes that the relationship between survey variables of interest and the size measure used for constructing the weight adjustment is the same for the population covered by MECS respondents within an adjustment stratum as it is for the rest of the population within that stratum.

To the extent that the nonresponding establishments within the adjustment cells share the energy consumption patterns of the responding establishments within strata, the resulting adjustments to the MECS estimates will tend to be minimally biased. If, on the other hand, the energy consumption patterns of the responding and nonresponding establishments differ substantially, the resulting adjustments are potentially biased, and may not represent the originally targeted MECS universe.

The cost-of-fuels ratio adjustment was a correction for differential changes in the MECS sample and the population which it represents. The comparison of the 1988 MECS estimate to the 1988 ASM estimate for electricity receipts indicated that the adjustment benefitted that MECS estimate. The expectation is that at the stratum by United States level and the region total level, the adjustment will provide large benefits. Most benefitted at these levels are the estimates for each of the major fuel consumption categories as each of these is expected to have a high correlation with cost of fuels.

The level of improvement at the region by stratum level is unclear. Within a stratum, the same cost of fuels ratio was used for each establishment. Thus, it is possible that for some estimates at the regional level the adjustment might have done more harm than good. EIA weighed this possibility against the expected benefits at the national level and decided to use the adjustment.

More detailed information on sources of nonsampling error in the MECS can be found in the methodological report.⁴²

⁴²Energy Information Administration, *Manufacturing Energy Consumption Survey: Methodological Report 1985*, DOE/EIA-0514(85).

Appendix C

MECS Coverage Related to EIA Supply Surveys

Appendix C

MECS Coverage Related to EIA Supply Surveys

The estimates of fuel-switching capability for combustible energy sources are based on the MECS measure of total inputs of energy for heat, power, and electricity generation. That measure represents a final-use accounting of energy used for its heat content, and is the appropriate measure on which to base estimates of fuel-switching capability. The MECS also collects information to estimate total primary consumption—a measure of the total requirement for energy sources, whether or not they are used for their energy content. The comparison of consumption estimates presented in this appendix is on the basis of total primary consumption.

In addition to the MECS, the EIA conducts a number of supply surveys. These surveys are directed to the suppliers and marketers of specific energy sources. They measure the quantities of specific energy sources produced and/or supplied to the market. The results of these surveys are published by EIA in several energy-specific publications and in the *Monthly Energy Review* (MER). There are important differences between the supply surveys and the MECS. These differences need to be taken into account in any analysis that uses both data sources.

In order to fully appreciate the differences between the MECS and the EIA supply surveys,⁴³ it is necessary to compare the MECS' measures of consumption to the supply surveys. Table C1 presents these estimates.

Table C1. Comparison of EIA Energy Consumption Estimates, 1988

Type of Energy	Manufacturing Only		Total Industrial Sector ^a		
	MECS	Quarterly Coal Report	Monthly Energy Review ^b	Electric Power Annual	Natural Gas Annual
Electricity (billion kilowatthours) . . .	703	--	896	896	--
Natural Gas (billion cubic feet)	5,695	--	7,479	--	6,383
Coal (thousand short tons)	97,582	69,546	118,162	--	--
Petroleum Products (thousand barrels per day)	1,112	--	4,381	--	--

^aThe industrial sector includes manufacturing, construction, mining, agriculture, and fishing and forestry.

^bThe consumption estimates presented in the *Monthly Energy Review* for the industrial sector are presented in British thermal units. These estimates have been converted to physical units for comparative purposes only.

Source: Energy Information Administration.

A major difference between the estimates for "Manufacturing Only" and the "Total Industrial Sector" in Table C1 is coverage. The manufacturing sector (SIC 20 through 39) includes establishments engaged in manufacturing operations, while the total industrial sector includes manufacturing as well as construction, mining, agriculture, and fishing and forestry (SIC 01 through 39). In addition, there are also differences in the respondents to the surveys. The unit of data collection in the MECS is the manufacturing establishment and the estimates represent energy consumption by manufacturing establishments. The unit of data collection

⁴³For further discussion of the discrepancy in supply and consumption data, see Energy Information Administration, *Energy Consumption by End-Use Sector: A Comparison of Measures by Consumption and Supply Surveys*, DOE/EIA-0533 (Washington, DC, April 6, 1990).

for the industrial sector surveys is an energy supplier—for example, a utility. The estimates represent *deliveries to customers*, which may not be the same as *consumption by establishments*. Moreover, the designation of a customer's account by an energy supplier is frequently based on the rate class to which a customer belongs rather than direct knowledge of a customer's type of operations. Therefore, it is likely that some "industrial" customers are, in fact, classified as "commercial," and visa versa, depending on their rate class. In addition, there are other differences that are specific to individual energy sources.

Electricity. The estimates of electricity from the MECS⁴⁴ represent "net electricity," defined as the sum of purchases, transfers in, and generation from noncombustible renewable resources, minus the quantities sold and transferred out. Net electricity does not include electricity inputs from the onsite cogeneration or generation of electricity from combustible fuels. The estimates of electricity appearing in the *Monthly Energy Review*⁴⁵ are taken directly from the *Electric Power Annual*⁴⁶. This estimate represents sales by electric utilities to industrial customers. Thus, in addition to the major differences outlined above, the estimates differ in the definition of electricity.

Natural Gas. The estimates of natural gas from the MECS represent consumption as a fuel and a raw material input by manufacturers. The estimates appearing in the MER represent sales to customers in the industrial sector and would also include natural gas consumed as a fuel and raw material input. The MER estimates are taken from the *Natural Gas Annual* and represent the sum lease and plant fuel consumption and deliveries to industrial customers.⁴⁷ Lease and plant fuel is consumed primarily at natural gas extraction sites, which are excluded from the MECS because they are classified as mining establishments.

Coal. There are numerous differences between the estimates of coal consumption as reported by the MECS and the *Quarterly Coal Report*. The estimates of coal consumption at manufacturing plants in the *Quarterly Coal Report*⁴⁸ are the only non-MECS estimates that are based on a survey of manufacturing establishments. Therefore, the difference between the MECS estimates and the estimates in the *Quarterly Coal Report* cannot be attributed to sectoral coverage or to the collection of delivery data rather than consumption data. There are, however, other differences between the two series. The MECS estimates include the coal consumed as a raw material input at coke plants. Coking coal is excluded from the manufacturing plant estimates in Table 30 of the *Quarterly Coal Report* and shown separately in Table 23 of that report. The sum of these two *Quarterly Coal Report* estimates is included as the industrial sector estimate in the MER. Moreover, the coal consumed at coal gasification projects is included in the manufacturing plant estimates appearing in Table 30 of the *Quarterly Coal Report*. These estimates are excluded from the MECS because such plants would be classified in the mining sector. Finally, the estimates for manufacturing plants appearing in Table 30 of the *Quarterly Coal Report* include the coal consumed at electric generating facilities owned by manufacturing plants, but not located on a manufacturing establishment site. These establishments are excluded from the MECS because, according to the *Standard Industrial Classification Manual*, such operations are not classified as manufacturing, but as "electrical services" (SIC 4911).⁴⁹

⁴⁴Energy Information Administration, *Manufacturing Energy Consumption Survey, Consumption of Energy 1988*, DOE/EIA-0512(88) (Washington, DC, May 28, 1991), Table 1.

⁴⁵Energy Information Administration, *Monthly Energy Review*, DOE/EIA-0035(91/05) (Washington, DC, May 1991), Table 2.4.

⁴⁶Energy Information Administration, *Electric Power Annual 1988*, DOE/EIA-0348(88) (Washington, DC, December 1989), Table 19.

⁴⁷Energy Information Administration, *Natural Gas Annual 1988, Volume 1*, DOE/EIA-0131(88)/1 (Washington, DC, October 1989), Tables 16 and 17.

⁴⁸Energy Information Administration, *Quarterly Coal Report, October - December 1989*, DOE/EIA-0121(89/4Q) (Washington, DC, May 1990), Table 30.

⁴⁹A special analysis was undertaken to determine which MECS manufacturing establishments received electricity from company-owned, offsite generation facilities. These identified generating facilities were then matched to the respondents to "Quarterly Coal Report—Manufacturing Plants," Form EIA-3. The coal consumed by these identified generating facilities accounted for much of the difference between the MECS estimates and those appearing in the *Quarterly Coal Report*. This analysis provided additional evidence that the separate estimates are, indeed, correct, given the populations that the respective surveys are intended to cover. Specific results of this analysis cannot be published because of the confidentiality provisions under which the MECS was conducted.

Petroleum Products. There are major differences between the MER estimates of total petroleum product and the MECS estimates. The MER estimate of petroleum products includes *all* of the petroleum products consumed by the industrial sector—aviation gasoline, asphalt, distillate fuel oil (including diesel fuel), jet fuel, kerosene, LPG, lubricants, motor gasoline, petroleum coke, and residual fuel oil. The MECS estimates shown in Table C1 include only distillate and residual fuel oil, and LPG.

Fuels Consumed at Refineries. In addition to estimates of the primary consumption of energy, the MECS publishes estimates of total inputs of energy for the production of heat and power.⁵⁰ These estimates are available for specific manufacturing industries including "petroleum refining," SIC 2911. Estimates of "refinery fuel use" are also published in the *Petroleum Supply Annual*.⁵¹ The MECS estimates for the fuel consumption by the petroleum refining industry are uniformly higher than the estimates appearing in the *Petroleum Supply Annual*. These differences are due to the fact that the estimates in the *Petroleum Supply Annual* are prepared from the "Annual Refinery Report," Form EIA-820, which collects data for petroleum processing operations (including refiners and blenders) only. The MECS data, on the other hand, cover the entire establishment site including any co-located petrochemical operations, which would be excluded from the EIA-820.

⁵⁰Energy Information Administration, *Manufacturing Energy Consumption Survey: Consumption of Energy 1988*, Table 3.

⁵¹Energy Information Administration, *Petroleum Supply Annual 1988, Volume 1*, DOE/EIA-0340(88)/1 (Washington, DC, May 1989), Table 38.

Appendix D

Manufacturing Energy Consumption Survey Forms

Appendix D

1988 Manufacturing Energy Consumption Survey Form EIA-846A

OMB No. 1905-0169: Approval Expires 04/30/91

FORM EIA-846A
(5-1-88)

U.S. DEPARTMENT OF COMMERCE
BUREAU OF THE CENSUS
ACTING AS COLLECTING AND COMPLYING AGENT FOR
UNITED STATES DEPARTMENT OF ENERGY
ENERGY INFORMATION ADMINISTRATION



1988 MANUFACTURING ENERGY CONSUMPTION SURVEY

NOTICE - This survey is mandatory under the Federal Energy Administration Act of 1974, P.L. 93-275, and under Title 3, Subtitle B of the Omnibus Budget Reconciliation Act of 1986, P.L. 99-509. Failure to respond may result in criminal fines, civil penalties, and other sanctions as provided by law. The confidentiality of your response to this survey is protected by law (title 13, U.S. Code). Your response may be seen only by certain Census employees and may be used only for statistical purposes. The law also provides that copies retained in your files are immune from legal process.

Public reporting burden for this collection of information is estimated to average 8 hours per response, including the time of reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to the Energy Information Administration, Office of Statistical Standards, EI-73, Mail Station, 1H-023 Forrestal, 1000 Independence Avenue, SW, Washington, DC 20485; and to the Office of Information and Regulatory Affairs, Office of Management and Budget, Washington, DC 20503.

In correspondence pertaining to this report, please refer to this Census File Number (CFN).

Please correct errors in name, address, and ZIP Code. ENTER street and number if not shown.

BUREAU OF THE CENSUS
1201 East Tenth Street
Jeffersonville, IN 47132

DUE DATE: JULY 20, 1989

If you cannot file by the due date, a time extension request should be sent to the above address, please include your 11-digit Census File Number (CFN).

NOTE

Please read the enclosed instructions before filling out this form. Complete each item. If you have any questions, call (301) 763-7066.

Section I - NONCOMBUSTIBLE ENERGY SOURCES

Item description (1)	Electricity (2)	Steam (3)	Industrial hot water (4)
	109 Kilowatthours Mil. Thou. kWh	117 Million Btu	125 Million Btu
1a. During 1988, what amount of each energy source was purchased by this establishment from outside and delivered to this establishment site?			
1b. What was the total expenditure for the purchased energy sources reported on line 1a?			
2a. During 1988, what amount of electricity and steam was purchased from nonutility suppliers by this establishment and delivered to this establishment site?			
2b. What was the total expenditure for the purchased electricity and steam reported on line 2a?			
3. During 1988, what amount of each energy source was transferred from outside establishments and delivered to this establishment site? Do not include the purchases reported in lines 1a or 2a.			
4. TOTAL electricity receipts. (Sum of lines 1a, 2a, and 3). NOTE - Copy this quantity to column 2, line 1 of Section III - FUEL SWITCHING.			
5. During 1988, how much electricity was generated on this establishment site by cogeneration?			
6. During 1988, how much of each energy source was generated onsite from solar power, wind power, hydropower, and geothermal sources?			
7. During 1988, how much electricity was generated onsite by processes other than those covered on lines 5 and 6?			
8. During 1988, how much electricity was sold or transferred to utilities?			
9. During 1988, how much of each energy source was sold or transferred to establishments other than utilities?			
10. If line 3, column 2 has a nonzero entry, and any of your electricity suppliers was another establishment of your company, identify that establishment at right. If you received electricity transfers from more than one establishment of your company, provide their identifying information in the "Remarks" section.	1 Name of energy supplier Address - Number and street City State ZIP Code Phone number		
Questions 11 and 12 below should be answered if this establishment generated any electricity onsite in 1988. If no electricity was generated onsite (column 2 has zero entries for lines 5, 6, and 7), omit questions 11 and 12 and proceed directly to Section II - Combustible Energy Sources.			
11. Was this establishment electrically interconnected with an electric utility (that is, able to deliver electricity to the grid as well as receive electricity) as of December 31, 1988?	1 <input type="checkbox"/> Yes 2 <input type="checkbox"/> No		
12. Was this establishment designated as a Qualifying Facility (QF) under Public Utility Regulatory Policies Act of 1978 (PURPA) as of December 31, 1988?	1 <input type="checkbox"/> Yes 2 <input type="checkbox"/> No		

1988 Manufacturing Energy Consumption Survey Form EIA-846A (Continued)

Section II - COMBUSTIBLE ENERGY SOURCES

Energy sources (1)	Census Use Only (2)	Units used for reporting quantities (3)	Energy sources received in 1988			
			Quantity purchased by and delivered to this establishment (4)	Total expenditure, including delivery charges, of the quantity in col. (4) (5)		Total other receipts (transfers in and central purchases) (6)
				Mil.	Thou.	Dol.
A. SOLIDS						
1. Anthracite	406	Short tons				
2. Bituminous and subbituminous coal	414					
3. Breeze	448					
4. Coal coke	430					
5. Lignite	422					
6. Total coal and coke (Sum of anthracite, bituminous and subbituminous coal, breeze, coal coke and lignite)	455					
7. Biomass	901	Million Btu				
8. Petroleum coke	703	Barrels				
9. Roundwood (wood cut specifically for fuel use)	802	Million Btu				
10. Waste materials (wastepaper, packing materials, etc.)	729					
11. Wood chips, bark, and wood waste	910					
12. Other solids (Specify)	919					
	927					
B. GASES						
1. Natural gas	307	1,000 cu. ft.				
2. Acetylene	646	Million Btu				
3. Blast furnace gas	604					
4. Coke oven gas	612					
5. Hydrogen	638					
6. Waste and byproduct gases (e.g., refinery off gas, vent gas, plant gas, still gas)	620					
7. Other gases (Specify)	935					
	943					
C. LIQUIDS						
1. Distillate fuel oil (numbers 1, 2, and 4 fuel oils and diesel)	224	Barrels				
2. Kerosene	273					
3. LPG (ethane, ethylene, propane, propylene, butane, butylene)	240	Gallons				
4. Motor gasoline	232					
5. Pulping or black liquor	737	Million Btu				
6. Residual fuel oil (numbers 5, 6, navy special, and bunker c)	216	Barrels				
7. Waste oils and tars	711	Million Btu				
8. Other liquids (Specify)	950					
	959					

Enter the total design storage capacity located onsite as of December 31, 1988, for:

1a. Distillate fuel oil 224 Barrels
 1b. Residual fuel oil 216 Barrels
 1c. LPG 240 Gallons

FORM EIA-846A (5-1-85)

Page 2

1988 Manufacturing Energy Consumption Survey Form EIA-846A (Continued)

Please enter this establishment's 11-digit Census File Number

Section II - COMBUSTIBLE ENERGY SOURCES - Continued

Energy sources produced onsite in 1988		Energy sources consumed onsite in 1988		Energy sources (11)	Census Use Only (12)
Quantity produced on-site (7)	Does the entry in col. (7) represent the product or byproduct of another energy source consumed on-site? (8)	Quantity consumed as a fuel (9)	Quantity consumed for all nonfuel purposes (10)		
A. SOLIDS					
				1. Anthracite	408
				2. Bituminous and subbituminous coal	414
	1 <input type="checkbox"/> Yes 2 <input type="checkbox"/> No			3. Breeze	448
	1 <input type="checkbox"/> Yes 2 <input type="checkbox"/> No			4. Coal coke	430
				5. Lignite	422
		Copy to line 1 of section 3		6. Total coal and coke (Sum of anthracite, bituminous and subbituminous coal, breeze, coal coke and lignite)	455
	1 <input type="checkbox"/> Yes 2 <input type="checkbox"/> No			7. Biomass	801
				8. Petroleum coke	703
				9. Roundwood (wood cut specifically for fuel use)	802
	1 <input type="checkbox"/> Yes 2 <input type="checkbox"/> No			10. Waste materials (wastepaper, packing materials, etc.)	729
	1 <input type="checkbox"/> Yes 2 <input type="checkbox"/> No			11. Wood chips, bark, and wood waste	810
	1 <input type="checkbox"/> Yes 2 <input type="checkbox"/> No			12. Other solids	819
	1 <input type="checkbox"/> Yes 2 <input type="checkbox"/> No				927
		Copy to line 1 of section 3		B. GASES	
	1 <input type="checkbox"/> Yes 2 <input type="checkbox"/> No			1. Natural gas	307
	1 <input type="checkbox"/> Yes 2 <input type="checkbox"/> No			2. Acetylene	848
	1 <input type="checkbox"/> Yes 2 <input type="checkbox"/> No			3. Blast furnace gas	804
	1 <input type="checkbox"/> Yes 2 <input type="checkbox"/> No			4. Coke oven gas	812
	1 <input type="checkbox"/> Yes 2 <input type="checkbox"/> No			5. Hydrogen	838
	1 <input type="checkbox"/> Yes 2 <input type="checkbox"/> No			6. Waste and byproduct gases (e.g., refinery off gas, vent gas, plant gas, still gas)	820
	1 <input type="checkbox"/> Yes 2 <input type="checkbox"/> No			7. Other gases	835
	1 <input type="checkbox"/> Yes 2 <input type="checkbox"/> No				843
		Copy to line 1 of section 3		C. LIQUIDS	
	1 <input type="checkbox"/> Yes 2 <input type="checkbox"/> No			1. Distillate fuel oil (numbers 1, 2, and 4 fuel oils and diesel)	224
	1 <input type="checkbox"/> Yes 2 <input type="checkbox"/> No			2. Kerosene	273
		Copy to line 1 of section 3		3. LPG (ethane, ethylene, propane, propylene, butane, butylene)	240
	1 <input type="checkbox"/> Yes 2 <input type="checkbox"/> No			4. Motor gasoline	282
	1 <input type="checkbox"/> Yes 2 <input type="checkbox"/> No			5. Pulping or black liquor	737
		Copy to line 1 of section 3		6. Residual fuel oil (numbers 5, 6, navy special, and bunker c)	216
	1 <input type="checkbox"/> Yes 2 <input type="checkbox"/> No			7. Waste oils and tars	711
	1 <input type="checkbox"/> Yes 2 <input type="checkbox"/> No			8. Other liquids	880
	1 <input type="checkbox"/> Yes 2 <input type="checkbox"/> No				988

1988 Manufacturing Energy Consumption Survey

Form EIA-846A (Continued)

Section III - FUEL SWITCHING

Item description (1)	Electricity (2) Kilowatthours	Total coal and coke (3) Short tons
1. Quantity consumed - Copy the total electricity receipts from line 4 of section I, and the quantities of coal and coke, natural gas, distillate fuel oil, LPG, and residual fuel oil consumed onsite as a fuel from column (9) of section II.		
<i>Now answer lines 2 and 3 as appropriate for the columns with nonzero entries in line 1. Do not consider differences in energy prices when estimating amounts.</i>	Kilowatthours	Short tons
2. Quantity nonswitchable - Enter the amount of the quantity in line 1 that could NOT have been replaced within 30 days by another energy source in 1988.		
3. Quantity switchable - Subtract line 2 from line 1 and enter the results. This represents the total quantity of energy consumption that COULD HAVE BEEN replaced within 30 days by one or more alternative energy sources in 1988.	Kilowatthours	Short tons
<i>Now answer lines 4a through 10b as appropriate for the columns with nonzero entries in line 3. Complete one column before starting another.</i>		Short tons
4a. Of the amount shown in line 3, what is the maximum amount that could have been replaced by electricity?		
4b. What is the minimum lead time required to make the switch to electricity?		1 <input type="checkbox"/> Less than 1 day 2 <input type="checkbox"/> 1 day to 1 week 3 <input type="checkbox"/> More than 1 week but within 30 days
5a. Of the amount shown in line 3, what is the maximum amount that could have been replaced by coal and coke?	Kilowatthours	
5b. What is the minimum lead time required to make the switch to coal and coke?		1 <input type="checkbox"/> Less than 1 day 2 <input type="checkbox"/> 1 day to 1 week 3 <input type="checkbox"/> More than 1 week but within 30 days
6a. Of the amount shown in line 3, what is the maximum amount that could have been replaced by natural gas?	Kilowatthours	Short tons
6b. What is the minimum lead time required to make the switch to natural gas?	1 <input type="checkbox"/> Less than 1 day 2 <input type="checkbox"/> 1 day to 1 week 3 <input type="checkbox"/> More than 1 week but within 30 days	1 <input type="checkbox"/> Less than 1 day 2 <input type="checkbox"/> 1 day to 1 week 3 <input type="checkbox"/> More than 1 week but within 30 days
7a. Of the amount shown in line 3, what is the maximum amount that could have been replaced by distillate fuel oil?	Kilowatthours	Short tons
7b. What is the minimum lead time required to make the switch to distillate fuel oil?	1 <input type="checkbox"/> Less than 1 day 2 <input type="checkbox"/> 1 day to 1 week 3 <input type="checkbox"/> More than 1 week but within 30 days	1 <input type="checkbox"/> Less than 1 day 2 <input type="checkbox"/> 1 day to 1 week 3 <input type="checkbox"/> More than 1 week but within 30 days
8a. Of the amount shown in line 3, what is the maximum amount that could have been replaced by LPG?	Kilowatthours	Short tons
8b. What is the minimum lead time required to make the switch to LPG?	1 <input type="checkbox"/> Less than 1 day 2 <input type="checkbox"/> 1 day to 1 week 3 <input type="checkbox"/> More than 1 week but within 30 days	1 <input type="checkbox"/> Less than 1 day 2 <input type="checkbox"/> 1 day to 1 week 3 <input type="checkbox"/> More than 1 week but within 30 days
9a. Of the amount shown in line 3, what is the maximum amount that could have been replaced by residual fuel oil?	Kilowatthours	Short tons
9b. What is the minimum lead time required to make the switch to residual fuel oil?	1 <input type="checkbox"/> Less than 1 day 2 <input type="checkbox"/> 1 day to 1 week 3 <input type="checkbox"/> More than 1 week but within 30 days	1 <input type="checkbox"/> Less than 1 day 2 <input type="checkbox"/> 1 day to 1 week 3 <input type="checkbox"/> More than 1 week but within 30 days
10a. Of the amount shown in line 3, what is the maximum amount that could have been replaced by any other energy source? Identify that energy source.	Kilowatthours	Short tons
10b. What is the minimum lead time required to make the switch to that energy source?	1 <input type="checkbox"/> Less than 1 day 2 <input type="checkbox"/> 1 day to 1 week 3 <input type="checkbox"/> More than 1 week but within 30 days	1 <input type="checkbox"/> Less than 1 day 2 <input type="checkbox"/> 1 day to 1 week 3 <input type="checkbox"/> More than 1 week but within 30 days

1988 Manufacturing Energy Consumption Survey Form EIA-846A (Continued)

Please enter this establishment's 11-digit Census File Number

Section III - FUEL SWITCHING - Continued

307 Natural gas (4) 1,000 cu. ft.	224 Distillate fuel oil (5) Barrels	240 LPG (6) Gallons	216 Residual fuel oil (7) Barrels
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1,000 cu. ft.	Barrels	Gallons	Barrels
---------------	---------	---------	---------

1,000 cu. ft.	Barrels	Gallons	Barrels
---------------	---------	---------	---------

1,000 cu. ft.	Barrels	Gallons	Barrels
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1 <input type="checkbox"/> Less than 1 day 2 <input type="checkbox"/> 1 day to 1 week 3 <input type="checkbox"/> More than 1 week but within 30 days	1 <input type="checkbox"/> Less than 1 day 2 <input type="checkbox"/> 1 day to 1 week 3 <input type="checkbox"/> More than 1 week but within 30 days	1 <input type="checkbox"/> Less than 1 day 2 <input type="checkbox"/> 1 day to 1 week 3 <input type="checkbox"/> More than 1 week but within 30 days	1 <input type="checkbox"/> Less than 1 day 2 <input type="checkbox"/> 1 day to 1 week 3 <input type="checkbox"/> More than 1 week but within 30 days
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1,000 cu. ft.	Barrels	Gallons	Barrels
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1 <input type="checkbox"/> Less than 1 day 2 <input type="checkbox"/> 1 day to 1 week 3 <input type="checkbox"/> More than 1 week but within 30 days	1 <input type="checkbox"/> Less than 1 day 2 <input type="checkbox"/> 1 day to 1 week 3 <input type="checkbox"/> More than 1 week but within 30 days	1 <input type="checkbox"/> Less than 1 day 2 <input type="checkbox"/> 1 day to 1 week 3 <input type="checkbox"/> More than 1 week but within 30 days	1 <input type="checkbox"/> Less than 1 day 2 <input type="checkbox"/> 1 day to 1 week 3 <input type="checkbox"/> More than 1 week but within 30 days
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1,000 cu. ft.	Barrels	Gallons	Barrels
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1 <input type="checkbox"/> Less than 1 day 2 <input type="checkbox"/> 1 day to 1 week 3 <input type="checkbox"/> More than 1 week but within 30 days	1 <input type="checkbox"/> Less than 1 day 2 <input type="checkbox"/> 1 day to 1 week 3 <input type="checkbox"/> More than 1 week but within 30 days	1 <input type="checkbox"/> Less than 1 day 2 <input type="checkbox"/> 1 day to 1 week 3 <input type="checkbox"/> More than 1 week but within 30 days	1 <input type="checkbox"/> Less than 1 day 2 <input type="checkbox"/> 1 day to 1 week 3 <input type="checkbox"/> More than 1 week but within 30 days
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1,000 cu. ft.	Gallons	Barrels	
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1 <input type="checkbox"/> Less than 1 day 2 <input type="checkbox"/> 1 day to 1 week 3 <input type="checkbox"/> More than 1 week but within 30 days		1 <input type="checkbox"/> Less than 1 day 2 <input type="checkbox"/> 1 day to 1 week 3 <input type="checkbox"/> More than 1 week but within 30 days	1 <input type="checkbox"/> Less than 1 day 2 <input type="checkbox"/> 1 day to 1 week 3 <input type="checkbox"/> More than 1 week but within 30 days
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1,000 cu. ft.	Barrels	Barrels	
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1 <input type="checkbox"/> Less than 1 day 2 <input type="checkbox"/> 1 day to 1 week 3 <input type="checkbox"/> More than 1 week but within 30 days	1 <input type="checkbox"/> Less than 1 day 2 <input type="checkbox"/> 1 day to 1 week 3 <input type="checkbox"/> More than 1 week but within 30 days		1 <input type="checkbox"/> Less than 1 day 2 <input type="checkbox"/> 1 day to 1 week 3 <input type="checkbox"/> More than 1 week but within 30 days
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1,000 cu. ft.	Barrels	Gallons	
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1 <input type="checkbox"/> Less than 1 day 2 <input type="checkbox"/> 1 day to 1 week 3 <input type="checkbox"/> More than 1 week but within 30 days	1 <input type="checkbox"/> Less than 1 day 2 <input type="checkbox"/> 1 day to 1 week 3 <input type="checkbox"/> More than 1 week but within 30 days	1 <input type="checkbox"/> Less than 1 day 2 <input type="checkbox"/> 1 day to 1 week 3 <input type="checkbox"/> More than 1 week but within 30 days	
--	--	--	--

1,000 cu. ft.	Barrels	Gallons	Barrels
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1 <input type="checkbox"/> Less than 1 day 2 <input type="checkbox"/> 1 day to 1 week 3 <input type="checkbox"/> More than 1 week but within 30 days	1 <input type="checkbox"/> Less than 1 day 2 <input type="checkbox"/> 1 day to 1 week 3 <input type="checkbox"/> More than 1 week but within 30 days	1 <input type="checkbox"/> Less than 1 day 2 <input type="checkbox"/> 1 day to 1 week 3 <input type="checkbox"/> More than 1 week but within 30 days	1 <input type="checkbox"/> Less than 1 day 2 <input type="checkbox"/> 1 day to 1 week 3 <input type="checkbox"/> More than 1 week but within 30 days
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FORM EIA-846A (11-1-88)

1988 Manufacturing Energy Consumption Survey Form EIA-846A (Continued)

Section IV — REMARKS — Please use this space or attach a separate sheet for any explanations that may be essential in understanding your reported data. Be sure to include the name, address, and telephone number of power generating establishments of your company that transferred or delivered electricity or steam to your establishment in 1988 if you did not have enough room in section I.

Section V — CERTIFICATION — The data in this report have been prepared in accordance with the instructions.

Name of person to contact regarding this report — <i>Print or type</i>		Area code	Number	Extension
		Telephone		
Address — Number and street		Period covered by this report FROM: Mo. Day Year TO: Mo. Day Year		
City	State	ZIP Code	Signature of authorized person	Date

FORM EIA-846A (5-1-88)

Page 6

1988 Manufacturing Energy Consumption Survey

Form EIA-846A (Continued)

EIA-846A-1
11-12-88

U.S. DEPARTMENT OF COMMERCE
BUREAU OF THE CENSUS

INSTRUCTIONS FOR FORM EIA-846A 1988 MANUFACTURING ENERGY CONSUMPTION SURVEY

A. Who Is Responsible for Conducting the Manufacturing Energy Consumption Survey?

The Manufacturing Energy Consumption Survey (MECS) was designed, and is being sponsored, by the Energy Information Administration (EIA) of the U.S. Department of Energy. The survey is being administered and compiled by the U.S. Bureau of the Census.

B. What Is The Purpose of This Survey?

The MECS will collect data on energy consumption and usage patterns for the manufacturing sector of the U.S. economy. In addition, it will measure the short-term (within 30 days) capability of your establishment to have used substitute fuels in place of those actually consumed in 1988. The information obtained from the MECS will be used to publish aggregate statistics on the consumption of energy for fuel and nonfuel uses, and on some energy-related issues such as energy prices, electricity generation onsite, and fuel-switching capabilities.

C. Who Should Report?

This survey is mandatory under the Federal Energy Administration Act of 1974, P.L. 93-275, and under Title 3, Subtitle B of the Omnibus Budget Reconciliation Act of 1986, Public Law 99-509.

This form is addressed to establishments operating primarily in the manufacturing sector, SIC 20 through 39, except for SIC 28, 29, and 3312, as defined by the 1987 Standard Industrial Classification Manual (SIC). Establishments operating in SIC 28, 29, or 3312, will complete similar MECS forms. Response by establishments included in the MECS sample selected for the survey and receiving the MECS survey form is required by law. Failure to respond may result in criminal fines, civil penalties, and other sanctions as provided by law.

D. How Is My Privacy Protected?

By Section 9 of Title 13, U.S. Code, your report to the Census Bureau is confidential. It may be seen only by sworn Census Bureau employees and may be used only for statistical purposes. The law also provides that copies retained in your files are immune from legal process.

E. When Is The Report Due?

The questionnaire should be returned by the due date specified on the form. Please use the enclosed return envelope. If the envelope has been misplaced, return the completed questionnaire to:

Bureau of the Census
1201 East Tenth Street
Jeffersonville, IN 47132

F. How Is a Manufacturing Establishment Defined?

A manufacturing establishment is an economic unit at a single physical location where the mechanical or chemical transformation of materials or substances into new products is performed. These operations are generally conducted in facilities described as plants, factories, or mills and characteristically use power-driven machines and material-handling equipment. Manufacturing also includes such activities as the assembly of components of manufactured products and the blending of materials such as lubricating oil, plastics, resins, or liquors.

An establishment is not necessarily identical to a business concern or firm, either of which may consist of one or more establishments. An establishment may consist of one or more units that

are engaged in separate or distinct activities. These units may be separated physically as well as economically, with separate records or substantially accurate reports available for each. If this establishment has previously completed the Annual Survey of Manufactures (ASM), Form MA-1000, conducted by the U.S. Census Bureau, establishment boundaries should correspond to those used for the ASM. Each unit should be treated as a separate establishment ONLY if that was the determination made for the ASM. Do not consolidate two ASM establishments into a single establishment for purposes of the MECS, or separate a single ASM establishment into two MECS establishments. Match the 11-digit Census File Number (CFN) located on the MECS questionnaire mailing label with the CFN on the ASM mailing label. Responses to MECS questions should include the same activities as those considered when responding to the matching ASM. If this establishment has never completed an ASM, report for all activities that occur at this physical location.

Section 1 — NONCOMBUSTIBLE ENERGY SOURCES

Energy sources used in manufacturing can be divided into two groups: combustible (capable of being burned), and noncombustible (such as electricity, steam, and industrial hot water). The purpose of section 1 is to collect 1988 data for noncombustible energy sources, in particular, electricity and steam.

Column 2 collects data that will provide important information on the components of electricity production, and permit an estimate to be made of the total consumption of electricity at your establishment. Column 3 collects data on the additional contribution that steam makes to the total consumption of energy at your establishment through net transfers and steam generated onsite by renewable energy sources. Column 4 collects data on hot water purchased for use as an energy source and used at this establishment site.

Electricity is to be reported in thousands of kilowatt-hours. Steam and industrial hot water are to be reported in millions of Btu. If you keep your records for steam in pounds, use a factor of 1,200 Btu per pound of steam to convert your data into Btu.

SPECIFIC INSTRUCTIONS

Line 1a — Quantity Purchased From Utilities —

Enter the quantity of each noncombustible energy source that was purchased from a utility and delivered to this establishment site in 1988, regardless of when payment was made. For purposes of this question, utilities are companies that produce and/or deliver electricity and/or natural gas, and are legally obligated to provide service to the general public within their franchise area. Utilities do not include such generators of electricity as independent power producers, small power producers, or cogenerators not located at this establishment site. Include quantities purchased for ANY onsite use, for example, production of heat and power, electrolysis processes, or steam cleaning. Exclude all:

- quantities purchased from independent power producers, small power producers, or cogenerators not located at this establishment site.
- quantities delivered from other establishments in your company even if those quantities were repurchased from them by your establishment.
- quantities purchased and paid for by a central purchasing entity separate from this establishment.
- quantities for which payment was made in-kind.

CONTINUE ON PAGE 2

1988 Manufacturing Energy Consumption Survey

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Page 2

Line 1b — Expenditures For Purchases From Utilities — Enter the total expenditures for the purchased quantities reported on line 1a. Include all expenditures regardless of when payment was actually made.

Line 2a — Quantity Purchased From Nonutilities — Enter the quantity of electricity and steam that was purchased from offsite nonutility power producers and delivered to this establishment site in 1988, regardless of when payment was made. Include quantities purchased for **ANY** onsite use. **Exclude** all:

- quantities delivered from other establishments in your company even if those quantities were repurchased from them by your establishment.
- quantities purchased and paid for by a central purchasing entity separate from this establishment.
- quantities for which payment was made in-kind.

Line 2b — Expenditures For Purchases From Nonutilities — Enter the total expenditures for the purchased quantities reported on line 2a. Include all expenditures regardless of when payment was actually made.

Line 3 — Other Receipts — Enter all additional quantities delivered to your establishment site in 1988 but not reported on lines 1a or 2a. **Include:**

- quantities purchased and paid for by a central purchasing entity separate from this establishment.
- quantities transferred from another establishment of your company for which payment was not made.
- quantities delivered from another establishment of your company even if those quantities were repurchased from them by your establishment.
- quantities for which payment was made in-kind.

Line 4 — Total Electricity Receipts — Enter the sum of lines 1a, 2a and 3 for electricity only. *Copy this total electricity receipt figure to column 2, line 1 of Section III — Fuel Switching.*

Line 5 — Quantity Cogenerated — Enter the total quantity of electricity cogenerated from all energy sources, including renewable sources. For purposes of this survey, electrical cogeneration is defined as the production of electric energy and another form of useful energy (such as heat or steam) through the sequential use of energy.

Line 6 — Quantity Generated from Renewables — Enter the total quantity of each noncombustible energy source generated onsite directly from solar power, wind power, hydropower, or geothermal sources. Any electricity produced as a part of a cogeneration process (that is, electricity generated from geothermal steam which is then itself used) should be excluded. Such quantities should be included on line 5.

Line 7 — Other Generation — Enter the total quantity of electricity generated onsite by all other means not included on lines 5 and 6 above. For example, electricity generated by diesel generators should be reported here.

Line 8 — Sales or Transfers to Utilities — Enter the total quantity of electricity sold or transferred by your establishment in 1988 to utilities. For purposes of this question, utilities are companies that produce and/or deliver electricity and/or natural gas, and are legally obligated to provide service to the general public within their franchise area. Utilities do not include such generators of electricity as independent power producers, small power producers, or cogenerators not located at this establishment site. Include quantities exchanged for the same or any other energy source(s).

Line 9 — Sales or Transfers to Nonutilities — Enter the total quantity of each noncombustible energy source sold or transferred in 1988 to establishments other than utilities. Include quantities exchanged for the same or any other energy source(s).

Line 10 — Nonutility Suppliers — If any electricity reported in column 2, line 3 was obtained by transfer from another establishment of your company, enter the name, address and telephone number of the supplying establishment. If you received transfers from more than one of this type of establishment, use the "Remarks" section to identify remaining suppliers.

Questions 11 and 12 should be completed if there was any electricity generated at this establishment site in 1988 (column 2 has a nonzero entry on lines 5, 6, or 7). If your establishment had no onsite generation in 1988, omit questions 11 and 12 and proceed with Section II — Combustible Energy Sources.

Question 11 — Indicate by checking the appropriate box whether or not this establishment was electrically interconnected with an electric utility (that is, able to deliver electricity to the grid as well as receive electricity) as of December 31, 1988.

Question 12 — Indicate by checking the appropriate box whether or not this establishment was designated as a Qualifying Facility (QF) under the Public Utility Regulatory Policies Act of 1978 (PURPA) as of December 31, 1988.

Section II — COMBUSTIBLE ENERGY SOURCES

Column 1 — Energy Sources to be Reported — Twenty-three energy sources have been preprinted in column 1, separated into the general categories of solids, gases, and liquids. Prior to completing columns 4 through 10, determine from the criteria below which of the preprinted energy sources should be included for reporting and which excluded.

First, **EXCLUDE** all energy sources that were not consumed for any purpose at this establishment site during 1988. All excluded energy sources should be lined out, and no entries should be made in columns 4 through 10. Next, if your establishment consumed any energy sources for any purpose during 1988 that are not included in the preprinted list, add those energy sources under the "Other" heading for solids, gases, or liquids.

All unlined energy sources, including any additions to the preprinted list, should be further evaluated for inclusion or exclusion by the specific criterion in the following paragraph.

1988 Manufacturing Energy Consumption Survey

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Page 3

If your only means of supply of an energy source during 1988 was as a byproduct of energy source inputs to any of your manufacturing processes, it should be included ONLY if it was at least partially consumed onsite as a fuel during 1988 (that is for heat, power, or electricity generation). If none of that onsite-produced energy source was consumed onsite as a fuel, it should be excluded.

Complete columns 4 through 10 for all energy sources that were not excluded by the above procedures. Entries should be made in accordance with the specific instructions for these columns.

Column 3 — Reporting Units — Use the indicated units for reporting all quantities. For those establishments that keep records in Btu, note that volume measures should be reported as actual physical quantities, rather than adjusted to represent a standard energy content. One barrel contains 42 gallons. The approximate liquid equivalent conversion factor of LPG is 3.603 million Btu per barrel. Petroleum coke should also be reported in barrels. A barrel will hold approximately 400 pounds of petroleum coke, or the equivalent of 6.024 million Btu. A short ton of petroleum coke contains approximately 30.12 million Btu. Natural gas should be reported in thousands of cubic feet. One thousand cubic feet of natural gas is equal to about 10.3 therms, or 1.03 million Btu.

Column 4 — Quantity Purchased — Enter the quantity of each energy source that was purchased and delivered to this establishment in 1988, regardless of when payment was made. Include quantities of those energy sources that were purchased for ANY onsite use, for example, the production of heat or power, electrolysis processes, steam cleaning, or as a petrochemical feedstock or a raw material input to any manufacturing operation. **Exclude all:**

- quantities delivered from another establishment in your company even if those quantities were repurchased from them by your establishment.
- quantities purchased and paid for by a central purchasing entity separate from this establishment.
- quantities for which payment was made in-kind.

Column 5 — Expenditures — Enter the total expenditures for each of the purchased quantities reported in column 4. Include all expenditures regardless of when payment was made.

Column 6 — Other Receipts — For each included energy source, enter all additional quantities delivered to your establishment site in 1988 but not reported in column 4. **Include:**

- quantities purchased and paid for by a central purchasing entity separate from this establishment.
- quantities transferred from another establishment of your company for which payment was not made.
- quantities delivered from another establishment of your company even if these quantities were repurchased from them by your establishment.
- quantities for which payment was made in-kind.

Column 7 — Onsite Production — Enter the total quantity of any energy source that was produced onsite in 1988 as a product, a byproduct, a waste material, or an output from a captive (onsite) mine or well, and was at least partially consumed onsite. Enter the TOTAL quantity produced onsite, regardless of whether some or all of it was consumed as a fuel or feedstock, transferred offsite, sold, or otherwise disposed of. Examples of byproducts include coke, hydrogen, still gas, coke oven gas, wood chips and black liquor. Examples of waste products include wood scraps, packing materials, waste paper and cardboard, and waste oils.

Column 8 — Source of Onsite Production — For each energy source that has an entry in column 7, check the "Yes" box if the amount listed in column 7 resulted from consumption of any other energy source listed in Section II — Combustible Energy Sources. Check the "No" box if the energy source came from captive wells or mines, or is a product or byproduct/waste product from materials not listed in section II as a combustible energy source. Examples include:

- hydrogen produced as a byproduct of natural gas in an ammonia plant would have the "Yes" box checked.
- hydrogen produced through the electrolysis of brine in a chlorine plant would have the "No" box checked.
- coke oven gas produced during the coal coking process would have the "Yes" box checked.
- wood chips produced as a byproduct of wood purchased for use as a raw material rather than a fuel would have the "No" box checked.
- pulping (black) liquor, used in the chemical pulping of wood, that is burned in a recovery furnace or otherwise combusted, would have the "No" box checked.

Column 9 — Onsite Fuel Consumption — Enter the quantity consumed onsite as a fuel for the production of heat, steam, power, or the generation of electricity. Also include fuel consumed by vehicles dedicated primarily for use onsite. Copy the entries, if any, in column 9 for natural gas, distillate fuel oil, residual fuel oil, LPG, and total coal products to line 1 of Section III — Fuel Switching.

Column 10 — Onsite Nonfuel Consumption — Enter the quantity of each energy source that was consumed onsite for all purposes other than fuel use. Include all quantities consumed as feedstocks (for example, butane processed in producing rubber compounds), raw materials (for example, coal used to produce coke), additives, or ingredients for products manufactured by this establishment. **Exclude all offsite dispositions such as sales and transfers to other establishments.**

Question 1 — Enter the total design storage capacity located onsite as of December 31, 1988, for residual fuel oil, distillate fuel oil, and LPG. Report the shell capacity (that is, the design capacity of the storage tanks) in the units of measure specified. **Include:**

- Onsite capacity of all storage facilities regardless of the intended disposition of the energy source (include both product storage tanks and tanks dedicated for onsite use).
- Onsite capacity dedicated or leased for storage of energy sources owned by other establishments.

1988 Manufacturing Energy Consumption Survey

Form EIA-846A (Continued)

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Section III — FUEL SWITCHING

This portion of the survey is intended to measure the short-term capability of your establishment to have used substitute energy sources in place of those actually consumed in 1988. Capability to use substitute energy sources means that this establishment's combustors (for example, boilers, furnaces, ovens, blast furnaces) had the machinery or equipment either in place or available for installation in 1988 so that substitutions could actually have been introduced within 30 days without extensive modifications.

NOTE — Fuel-switching capability as measured by this survey does not depend on the relative prices of energy sources; it depends only on the characteristics of your equipment and certain legal constraints. Fuel-switching capability sets limits on the extent to which you could switch to a substitute energy source if you wanted to or needed to. It has nothing to do with whether you would want to switch if you could. Therefore, relative prices of energy sources are not related to fuel-switching CAPABILITY and should be ignored when completing this section.

We recognize that records of fuel-switching capability are not regularly maintained. Accordingly, reasonable approximations of fuel-switching capability are acceptable. These approximations should be based on the judgment of a person knowledgeable about the fuel-switching capability and operations of your establishment. They are not expected to be formal engineering estimates based on a day-by-day analysis of the operating levels of individual combustors and interactions between them. Respond as realistically as possible, given your actual operations in 1988.

Base your estimates on the availability of substitute energy sources and the physical condition of your equipment during 1988. Include switching capability that could have resulted from the use of redundant and/or standby combustors, and from combustors that were already equipped to fire alternative fuels. Lines 1 through 3 of this portion of the form measure your establishment's overall capability to have switched from specific energy sources in 1988. Lines 4a through 10b describe your capability to replace a given energy source by specific alternative energy sources.

SPECIFIC INSTRUCTIONS

Line 1 — Quantity Consumed — Enter the total electricity receipts figure from column 2, line 4 of Section I, and the fuel consumption figures from Section II for total coal and coke, natural gas, distillate fuel oil, LPG, and residual fuel oil. The quantities to be copied are noted in the appropriate boxes of sections I and II.

Line 2 — Quantity Nonswitchable — Enter the amount of the quantity reported on Line 1 that could NOT have been replaced within 30 days by any other energy source in 1988, even given a severe curtailment. **NOTE** — Include only that portion of total electricity receipts (purchases plus transfers in) that could NOT have been replaced by either on-site-generated electricity or energy source(s) which accomplish the same purposes as the off-site-produced electricity (e.g., supplying heat or power). Portions of individual fuels may be non-switchable due to limitations such as:

- the characteristics of your physical plant (for example, single-fired combustors or the absence of redundant and/or standby combustors), or the requirements of your manufacturing process.
- binding take or pay contracts with energy suppliers that were in place.
- environmental regulations which limit the amounts of potential replacement fuels that could be burned.

DO NOT consider current relative prices of fuels as a limitation to switching capability.

Line 3 — Quantity Switchable — Subtract line 2 from line 1 and enter the results. These values represent the quantity of each energy source consumed that COULD HAVE BEEN replaced within 30 days by at least one other energy source in 1988. **NOTE** — If all entries on line 3 are zero, complete the Remarks and Certification sections of the survey and return it to the Census Bureau. For each entry on line 3 that is nonzero, complete the remainder of that column. Complete one column before starting another.

Lines 4 through 10, Part a — Replacement Quantities — Report the maximum amount of the quantity shown on Line 3 that could have been replaced within 30 days by each of the energy sources on lines 4 through 10, under the constraints listed in the instructions for line 2. Report all amounts in the units of the energy source that is being replaced. DO NOT convert this amount to units of the replacement energy sources. **NOTE** — Be sure to take into account not only the fuels that could be directly substituted for off-site-produced electricity, but also the fuels needed to generate electricity on-site that could have been used in place of electricity receipts.

NOTE — The sum of lines 4a through 10a for each column must be at least as large as the entry on line 3 of that column, and may be larger if more than one alternative fuel could have been used.

Lines 4 through 10, Part b — Lead Time — Mark the minimum lead time required to switch to each replacement energy source identified.

Section IV — REMARKS

Please provide any explanations that may be helpful to us in understanding your reported data. Attach a separate sheet if necessary. Be sure to include the name, address, and telephone number of nonutility power generating establishments of your company that supplied electricity to your establishment if you did not have enough room in section I to identify them.

Section V — CERTIFICATION

Period Covered By This Report — Enter the month, day, and year of the beginning and the end of the period covered by your report. If a calendar year report: "From January 1 to December 31, 1988,"; if a fiscal year, specify which (such as "From December 1, 1987 to November 30, 1988"). If a part-year report is submitted because the establishment was not in operation or under your company's control for the entire year, specify the actual period covered: for example "January 2, 1988 to August 15, 1988," or "June 1, 1988 to December 31, 1988."

1988 Manufacturing Energy Consumption Survey

Form EIA-846B

OMB No. 1805-0168; Approval Expires 04/30/91

Public reporting burden for this collection of information is estimated to average 5 hours per response, including the time of reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Avenue, NW, Washington, DC 20540, and to the Office of Management and Budget, Paperwork Project Director (0304-0188), Washington, DC 20503.



U.S. DEPARTMENT OF COMMERCE
BUREAU OF THE CENSUS
ACTING AS COLLECTING AND CONTROLLING AGENCY FOR
UNITED STATES DEPARTMENT OF ENERGY
ENERGY INFORMATION ADMINISTRATION

1988 MANUFACTURING ENERGY CONSUMPTION SURVEY

NOTICE - This survey is mandatory under the Federal Energy Administration Act of 1974, P.L. 93-275, and under Title 3, Subtitle B of 54 Statute Book, Reorganization Act of 1950, P.L. 86-508. Failure to respond may result in criminal penalties, civil penalties, and other sanctions as provided by law. The survey is conducted by the Bureau of the Census, U.S. Department of Commerce.

NOTE: Please read the enclosed instructions before filling out this form. Complete each item. If you have any questions, call (800) 753-7000.

Section I - NONCOMBUSTIBLE ENERGY SOURCES

Item description	(1)	(2)	(3)	(4)
During 1988, what amount of each energy source was purchased by this establishment from outside sources and delivered to the establishment?	MM. Thou.	MM. Thou.	MM. Thou.	MM. Thou.
During 1988, what amount of electricity and steam was purchased from outside sources and delivered to the establishment?	MM. Thou.	MM. Thou.	MM. Thou.	MM. Thou.
During 1988, what amount of electricity was generated on the establishment site by cogeneration?	MM. Thou.	MM. Thou.	MM. Thou.	MM. Thou.
During 1988, how much of each energy source was generated by processes other than those covered in lines 2 and 3?	MM. Thou.	MM. Thou.	MM. Thou.	MM. Thou.
During 1988, how much electricity was sold or transferred to utilities?	MM. Thou.	MM. Thou.	MM. Thou.	MM. Thou.
During 1988, how much of each energy source was sold or transferred to establishments other than utilities?	MM. Thou.	MM. Thou.	MM. Thou.	MM. Thou.

10. If line 3, column 2 has a nonzero entry, and any of your electricity suppliers was another establishment at your location, identify that establishment at the top of column 2. If you received electricity from more than one establishment at your location, provide that identifying information in the "Remarks" section.

11. Questions 11 and 12 below should be answered if this establishment generated any electricity in 1988. If no electricity was generated on-site, column 2 has zero entries for lines 6, 7, and 8, and 11 and 12 are not answered.

12. Was this establishment electrically interconnected with an electric utility that is able to deliver electricity to the grid as well as receive electricity as of December 31, 1988? ☐ Yes ☐ No

13. Was this establishment designated as a Qualifying Facility (QF) under Public Utility Regulatory Policies Act of 1978 (PURA) as of December 31, 1988? ☐ Yes ☐ No

1988 Manufacturing Energy Consumption Survey

Form EIA-846B (Continued)

Section II - COMBUSTIBLE ENERGY SOURCES

For purposes of this portion of the survey, a refinery is an installation that manufactures finished petroleum products from crude oil, unfinished oils, natural gas liquids, other hydrocarbons, and alcohol. Products include motor gasoline, unfinished oils, aviation gasoline, special naphthas, kerosene, distillate fuel oil, residual fuel oil, lubricating oils, asphalt and road oil, waxes, petroleum coke, still gas and petrochemical feedstocks. Nonrefinery or petrochemical operations produce substances by the chemical treatment of raw materials derived from petroleum or natural gas. Among the final products are plastics (including synthetic rubbers), synthetic fibers, chemicals, drugs, and detergents.

Check the box next to the correct description of the establishment identified on the address label. Then supply data for Section II according to the instructions for that description.

CLASSIFICATION	INSTRUCTIONS
1 <input type="checkbox"/> Establishment consists of REFINERY operations ONLY. (There may be nonrefinery (petrochemical) operations collocated, but those operations are identified as a separate establishment for purposes of the Annual Survey of Manufactures, Census Form MA-1000.)	Complete Version A of Section II but do NOT make any entries in columns 9 and 10. Ignore Version B of Section II on pages 4 and 5.
2 <input type="checkbox"/> Establishment consists of both REFINERY AND NONREFINERY operations.	Complete Version A of Section II INCLUDING columns 9 and 10. Ignore Version B of Section II on pages 4 and 5.
3 <input type="checkbox"/> Establishment consists of NONREFINERY operations ONLY. (There may be collocated refinery operations but these operations are identified as a separate establishment for purposes of the Annual Survey of Manufactures, Census Form MA-1000.)	Complete Version B of Section II on pages 4 and 5. Ignore Version A.

VERSION A

Energy sources (1)	Census Use Only (2)	Units used for reporting quantities (3)	Enter amounts for entire establishment				
			Quantity purchased by and delivered to this establishment (4)	Total expenditure, including delivery charges, for the quantity in col. (4) (5)			Total other receipts (transfers in and central purchases) (6)
				Mil.	Thou.	Dol.	
A. PETROLEUM BASED							
1. Crude oil/lease condensate	208	Barrels					
2. Residual fuel oil (numbers 5, 6, navy special, and bunker c)	216						
3. Distillate fuel oil (numbers 1, 2, and 4 fuel oils and diesel)	224						
4. LPG (ethane, ethylene, propane, propylene, butane, butylene)	240	Gallons					
5. Motor gasoline	232	Million Btu					
6. Waste and byproduct gases (e.g., refinery off gas, vent gas, plant gas, still gas)	620						
7. Petroleum coke	703	Barrels					
8. Waste oils and tars	711	Million Btu					
9. Other (Specify)	950						
	968						
B. NONPETROLEUM BASED							
1. Anthracite	406	Short tons					
2. Bituminous and subbituminous coal	414						
3. Breeze	448						
4. Coal coke	430						
5. Lignite	422						
6. Total coal and coke (Sum of anthracite, bituminous and subbituminous coal, breeze, coal coke and lignite)	455						
7. Natural gas	307	1,000 cu. ft.					
8. Hydrogen	638	Million Btu					
9. Waste materials (wastepaper, packing materials, etc.)	729						
10. Other (Specify)	976						
	984						

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1988 Manufacturing Energy Consumption Survey Form EIA-846B (Continued)

Please enter this establishment's 11-digit Census File Number

Section II - COMBUSTIBLE ENERGY SOURCES - Continued

VERSION A - Continued

Enter amounts for entire establishment		Enter amount for nonrefinery operations only		Energy sources (11)	Census Use Only 201 (12)
Quantity of each energy source produced onsite (7)	Quantity consumed onsite as a fuel (8)	Quantity consumed onsite for all nonfuel purposes (9)	Shipments offsite to other establishments (10)		
				A. PETROLEUM BASED	
				1. Crude oil/lease condensate	208
Copy to line 1 of section 3				2. Residual fuel oil (numbers 5, 6, navy special, and bunker c)	216
Copy to line 1 of section 3				3. Distillate fuel oil (numbers 1, 2, and 4 fuel oils and diesel)	224
Copy to line 1 of section 3				4. LPG (ethane, ethylene, propane, propylene, butane, butylene)	240
				5. Motor gasoline	232
				6. Waste and byproduct gases (e.g., refinery off gas, vent gas, plant gas, still gas)	620
				7. Petroleum coke	703
				8. Waste oils and tars	711
				9. Other	950
					968
				B. NONPETROLEUM BASED	
				1. Anthracite	408
				2. Bituminous and subbituminous coal	414
				3. Breeze	448
				4. Coal coke	430
				5. Lignite	422
Copy to line 1 of section 3				6. Total coal and coke (Sum of anthracite, bituminous and subbituminous coal, breeze, coal coke and lignite)	455
				7. Natural gas	307
				8. Hydrogen	638
				9. Waste materials (wastepaper, packing materials, etc.)	729
				10. Other	976
					984

FORM EIA-846B (5-1-85)

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1988 Manufacturing Energy Consumption Survey Form EIA-846B (Continued)

Section II — COMBUSTIBLE ENERGY SOURCES — VERSION B

Energy sources (1)	Census Use Only (2)	Units used for reporting quantities (3)	Energy sources received in 1988				Total other receipts (transfers in and central purchases) (6)
			Quantity purchased by and delivered to this establishment (4)	Total expenditure, including delivery charges, of the quantity in col. (4) (5)			
				Mill.	Thou.	Dol.	
A. SOLIDS							
1. Anthracite	408	Short tons					
2. Bituminous and subbituminous coal	414						
3. Breeze	448						
4. Coal coke	430						
5. Lignite	422						
6. Total coal and coke (Sum of anthracite, bituminous and subbituminous coal, breeze, coal coke and lignite)	455						
7. Biomass	901	Million Btu					
8. Petroleum coke	703	Barrels					
9. Roundwood (wood cut specifically for fuel use)	802	Million Btu					
10. Waste materials (wastepaper, packing materials, etc.)	729						
11. Wood chips, bark, and wood waste	810						
12. Other solids (Specify)	919						
	927						
B. GASES		1,000 cu. ft.					
1. Natural gas	307	Million Btu					
2. Acetylene	846						
3. Blast furnace gas	804						
4. Coke oven gas	812						
5. Hydrogen	638						
6. Waste and byproduct gases (e.g., refinery off gas, vent gas, plant gas, still gas)	820						
7. Other gases (Specify)	935						
	943						
C. LIQUIDS							
1. Distillate fuel oil (numbers 1, 2, and 4 fuel oils and diesel)	224	Barrels					
2. Kerosene	273	Gallons					
3. LPG (ethane, ethylene, propane, propylene, butane, butylene)	240						
4. Motor gasoline	232	Million Btu					
5. Pulp and black liquor	737	Barrels					
6. Residual fuel oil (numbers 5, 6, navy special, and bunker c)	216	Million Btu					
7. Waste oils and tars	711						
8. Other liquids (Specify)	950						
	968						

For the purposes of questions 1, 2a, and 2b below, energy sources include: acetylene, breeze, butane/butylene, coal coke, distillate fuel oil, ethane/ethylene, isobutane, petroleum coke, propane/propylene, and residual fuel oil.

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1. Total Btu content of energy source products shipped during 1988. Million Btu

If the answer to question 1 is zero, omit questions 2a and 2b and proceed directly to question 3 on page 5.

If question 1 has a nonzero response, include in the answers to questions 2a and 2b only those energy source products that were reported in question 1.

2a. Total Btu value of all energy source inventories as of December 31, 1987. Million Btu

2b. Total Btu value of all energy source inventories as of December 31, 1988. Million Btu

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1988 Manufacturing Energy Consumption Survey Form EIA-846B (Continued)

Please enter this establishment's 11-digit Census File Number

Section II - COMBUSTIBLE ENERGY SOURCES - VERSION B - Continued

Energy sources produced onsite in 1988		Energy sources consumed onsite in 1988		Energy sources (11)	Census Use Only (12)
Quantity produced onsite (7)	Does the entry in col. (7) represent the product or byproduct of another energy source consumed onsite? (8)	Quantity consumed as a fuel (9)	Quantity consumed for all nonfuel purposes (10)		
				A. SOLIDS	
				1. Anthracite	406
				2. Bituminous and subbituminous coal	414
	1 <input type="checkbox"/> Yes 2 <input type="checkbox"/> No			3. Breeze	448
	1 <input type="checkbox"/> Yes 2 <input type="checkbox"/> No			4. Coal coke	430
				5. Lignite	422
		Copy to line 1 of section 3		6. Total coal and coke (Sum of anthracite, bituminous and subbituminous coal, breeze, coal coke and lignite)	465
	1 <input type="checkbox"/> Yes 2 <input type="checkbox"/> No			7. Biomass	901
				8. Petroleum coke	703
				9. Roundwood (wood cut specifically for fuel use)	802
				10. Waste materials (wastepaper, packing materials, etc.)	729
	1 <input type="checkbox"/> Yes 2 <input type="checkbox"/> No			11. Wood chips, bark, and wood waste	810
	1 <input type="checkbox"/> Yes 2 <input type="checkbox"/> No			12. Other solids	919
	1 <input type="checkbox"/> Yes 2 <input type="checkbox"/> No				927
		Copy to line 1 of section 3		B. GASES	
	1 <input type="checkbox"/> Yes 2 <input type="checkbox"/> No			1. Natural gas	307
	1 <input type="checkbox"/> Yes 2 <input type="checkbox"/> No			2. Acetylene	946
	1 <input type="checkbox"/> Yes 2 <input type="checkbox"/> No			3. Blast furnace gas	604
	1 <input type="checkbox"/> Yes 2 <input type="checkbox"/> No			4. Coke oven gas	612
	1 <input type="checkbox"/> Yes 2 <input type="checkbox"/> No			5. Hydrogen	638
	1 <input type="checkbox"/> Yes 2 <input type="checkbox"/> No			6. Waste and byproduct gases (e.g., refinery off gas, vent gas, plant gas, still gas)	620
	1 <input type="checkbox"/> Yes 2 <input type="checkbox"/> No			7. Other gases	935
	1 <input type="checkbox"/> Yes 2 <input type="checkbox"/> No				943
		Copy to line 1 of section 3		C. LIQUIDS	
	1 <input type="checkbox"/> Yes 2 <input type="checkbox"/> No			1. Distillate fuel oil (numbers 1, 2, and 4 fuel oils and diesel)	224
	1 <input type="checkbox"/> Yes 2 <input type="checkbox"/> No			2. Kerosene	273
	1 <input type="checkbox"/> Yes 2 <input type="checkbox"/> No	Copy to line 1 of section 3		3. LPG (ethane, ethylene, propane, propylene, butane, butylene)	240
	1 <input type="checkbox"/> Yes 2 <input type="checkbox"/> No			4. Motor gasoline	232
	1 <input type="checkbox"/> Yes 2 <input type="checkbox"/> No			5. Pulping or black liquor	737
	1 <input type="checkbox"/> Yes 2 <input type="checkbox"/> No	Copy to line 1 of section 3		6. Residual fuel oil (numbers 5, 6, navy special, and bunker c)	216
	1 <input type="checkbox"/> Yes 2 <input type="checkbox"/> No			7. Waste oils and tars	711
	1 <input type="checkbox"/> Yes 2 <input type="checkbox"/> No			8. Other liquids	950
	1 <input type="checkbox"/> Yes 2 <input type="checkbox"/> No				968

8. Enter the total design storage capacity located onsite as of December 31, 1988 for:

8a. Distillate fuel oil 224 Barrels

8b. Residual fuel oil 216 Barrels

8c. LPG 240 Gallons

1988 Manufacturing Energy Consumption Survey Form EIA-846B (Continued)

Section III - FUEL SWITCHING

Item description (1)	109 Electricity (2) Kilowatthours	455 Total coal and coke (3) Short tons
1. Quantity consumed — Copy the total electricity receipts from line 4 of section I, and the quantities of coal and coke, natural gas, distillate fuel oil, LPG, and residual fuel oil consumed onsite as a fuel from column (8) of section II, version A or column (9) of section II, version B. <i>Now answer lines 2 and 3 as appropriate for the columns with nonzero entries in line 1. Do not consider differences in energy prices when estimating amounts.</i>	Kilowatthours	Short tons
2. Quantity nonswitchable — Enter the amount of the quantity in line 1 that could NOT have been replaced within 30 days by another energy source in 1988.	Kilowatthours	Short tons
3. Quantity switchable — Subtract line 2 from line 1 and enter the results. This represents the total quantity of energy consumption that COULD HAVE BEEN replaced within 30 days by one or more alternative energy sources in 1988. <i>Now answer lines 4a through 10b as appropriate for the columns with nonzero entries in line 3. Complete one column before starting another.</i>	Kilowatthours	Short tons
4a. Of the amount shown in line 3, what is the maximum amount that could have been replaced by electricity?		
4b. What is the minimum lead time required to make the switch to electricity?		1 <input type="checkbox"/> Less than 1 day 2 <input type="checkbox"/> 1 day to 1 week 3 <input type="checkbox"/> More than 1 week but within 30 days
5a. Of the amount shown in line 3, what is the maximum amount that could have been replaced by coal and coke?	Kilowatthours	
5b. What is the minimum lead time required to make the switch to coal and coke?	1 <input type="checkbox"/> Less than 1 day 2 <input type="checkbox"/> 1 day to 1 week 3 <input type="checkbox"/> More than 1 week but within 30 days	
6a. Of the amount shown in line 3, what is the maximum amount that could have been replaced by natural gas?	Kilowatthours	Short tons
6b. What is the minimum lead time required to make the switch to natural gas?	1 <input type="checkbox"/> Less than 1 day 2 <input type="checkbox"/> 1 day to 1 week 3 <input type="checkbox"/> More than 1 week but within 30 days	1 <input type="checkbox"/> Less than 1 day 2 <input type="checkbox"/> 1 day to 1 week 3 <input type="checkbox"/> More than 1 week but within 30 days
7a. Of the amount shown in line 3, what is the maximum amount that could have been replaced by distillate fuel oil?	Kilowatthours	Short tons
7b. What is the minimum lead time required to make the switch to distillate fuel oil?	1 <input type="checkbox"/> Less than 1 day 2 <input type="checkbox"/> 1 day to 1 week 3 <input type="checkbox"/> More than 1 week but within 30 days	1 <input type="checkbox"/> Less than 1 day 2 <input type="checkbox"/> 1 day to 1 week 3 <input type="checkbox"/> More than 1 week but within 30 days
8a. Of the amount shown in line 3, what is the maximum amount that could have been replaced by LPG?	Kilowatthours	Short tons
8b. What is the minimum lead time required to make the switch to LPG?	1 <input type="checkbox"/> Less than 1 day 2 <input type="checkbox"/> 1 day to 1 week 3 <input type="checkbox"/> More than 1 week but within 30 days	1 <input type="checkbox"/> Less than 1 day 2 <input type="checkbox"/> 1 day to 1 week 3 <input type="checkbox"/> More than 1 week but within 30 days
9a. Of the amount shown in line 3, what is the maximum amount that could have been replaced by residual fuel oil?	Kilowatthours	Short tons
9b. What is the minimum lead time required to make the switch to residual fuel oil?	1 <input type="checkbox"/> Less than 1 day 2 <input type="checkbox"/> 1 day to 1 week 3 <input type="checkbox"/> More than 1 week but within 30 days	1 <input type="checkbox"/> Less than 1 day 2 <input type="checkbox"/> 1 day to 1 week 3 <input type="checkbox"/> More than 1 week but within 30 days
10a. Of the amount shown in line 3, what is the maximum amount that could have been replaced by any other energy source? <i>Identify that energy source.</i>	Kilowatthours	Short tons
10b. What is the minimum lead time required to make the switch to that energy source?	1 <input type="checkbox"/> Less than 1 day 2 <input type="checkbox"/> 1 day to 1 week 3 <input type="checkbox"/> More than 1 week but within 30 days	1 <input type="checkbox"/> Less than 1 day 2 <input type="checkbox"/> 1 day to 1 week 3 <input type="checkbox"/> More than 1 week but within 30 days

1988 Manufacturing Energy Consumption Survey Form EIA-846B (Continued)

Please enter this establishment's 11-digit Census File Number

Section III - FUEL SWITCHING - Continued

307 Natural gas (4) 1,000 cu. ft.	224 Distillate fuel oil (5) Barrels	240 LPG (6) Gallons	218 Residual fuel oil (7) Barrels
1,000 cu. ft.	Barrels	Gallons	Barrels
1,000 cu. ft.	Barrels	Gallons	Barrels
1,000 cu. ft.	Barrels	Gallons	Barrels
1,000 cu. ft.	Barrels	Gallons	Barrels
1 <input type="checkbox"/> Less than 1 day 2 <input type="checkbox"/> 1 day to 1 week 3 <input type="checkbox"/> More than 1 week but within 30 days	1 <input type="checkbox"/> Less than 1 day 2 <input type="checkbox"/> 1 day to 1 week 3 <input type="checkbox"/> More than 1 week but within 30 days	1 <input type="checkbox"/> Less than 1 day 2 <input type="checkbox"/> 1 day to 1 week 3 <input type="checkbox"/> More than 1 week but within 30 days	1 <input type="checkbox"/> Less than 1 day 2 <input type="checkbox"/> 1 day to 1 week 3 <input type="checkbox"/> More than 1 week but within 30 days
1,000 cu. ft.	Barrels	Gallons	Barrels
1 <input type="checkbox"/> Less than 1 day 2 <input type="checkbox"/> 1 day to 1 week 3 <input type="checkbox"/> More than 1 week but within 30 days	1 <input type="checkbox"/> Less than 1 day 2 <input type="checkbox"/> 1 day to 1 week 3 <input type="checkbox"/> More than 1 week but within 30 days	1 <input type="checkbox"/> Less than 1 day 2 <input type="checkbox"/> 1 day to 1 week 3 <input type="checkbox"/> More than 1 week but within 30 days	1 <input type="checkbox"/> Less than 1 day 2 <input type="checkbox"/> 1 day to 1 week 3 <input type="checkbox"/> More than 1 week but within 30 days
1,000 cu. ft.	Barrels	Gallons	Barrels
1 <input type="checkbox"/> Less than 1 day 2 <input type="checkbox"/> 1 day to 1 week 3 <input type="checkbox"/> More than 1 week but within 30 days	1 <input type="checkbox"/> Less than 1 day 2 <input type="checkbox"/> 1 day to 1 week 3 <input type="checkbox"/> More than 1 week but within 30 days	1 <input type="checkbox"/> Less than 1 day 2 <input type="checkbox"/> 1 day to 1 week 3 <input type="checkbox"/> More than 1 week but within 30 days	1 <input type="checkbox"/> Less than 1 day 2 <input type="checkbox"/> 1 day to 1 week 3 <input type="checkbox"/> More than 1 week but within 30 days
1,000 cu. ft.	Barrels	Gallons	Barrels
1 <input type="checkbox"/> Less than 1 day 2 <input type="checkbox"/> 1 day to 1 week 3 <input type="checkbox"/> More than 1 week but within 30 days	1 <input type="checkbox"/> Less than 1 day 2 <input type="checkbox"/> 1 day to 1 week 3 <input type="checkbox"/> More than 1 week but within 30 days	1 <input type="checkbox"/> Less than 1 day 2 <input type="checkbox"/> 1 day to 1 week 3 <input type="checkbox"/> More than 1 week but within 30 days	1 <input type="checkbox"/> Less than 1 day 2 <input type="checkbox"/> 1 day to 1 week 3 <input type="checkbox"/> More than 1 week but within 30 days
1,000 cu. ft.	Barrels	Gallons	Barrels
1 <input type="checkbox"/> Less than 1 day 2 <input type="checkbox"/> 1 day to 1 week 3 <input type="checkbox"/> More than 1 week but within 30 days	1 <input type="checkbox"/> Less than 1 day 2 <input type="checkbox"/> 1 day to 1 week 3 <input type="checkbox"/> More than 1 week but within 30 days	1 <input type="checkbox"/> Less than 1 day 2 <input type="checkbox"/> 1 day to 1 week 3 <input type="checkbox"/> More than 1 week but within 30 days	1 <input type="checkbox"/> Less than 1 day 2 <input type="checkbox"/> 1 day to 1 week 3 <input type="checkbox"/> More than 1 week but within 30 days
1,000 cu. ft.	Barrels	Gallons	Barrels
1 <input type="checkbox"/> Less than 1 day 2 <input type="checkbox"/> 1 day to 1 week 3 <input type="checkbox"/> More than 1 week but within 30 days	1 <input type="checkbox"/> Less than 1 day 2 <input type="checkbox"/> 1 day to 1 week 3 <input type="checkbox"/> More than 1 week but within 30 days	1 <input type="checkbox"/> Less than 1 day 2 <input type="checkbox"/> 1 day to 1 week 3 <input type="checkbox"/> More than 1 week but within 30 days	1 <input type="checkbox"/> Less than 1 day 2 <input type="checkbox"/> 1 day to 1 week 3 <input type="checkbox"/> More than 1 week but within 30 days
1,000 cu. ft.	Barrels	Gallons	Barrels
1 <input type="checkbox"/> Less than 1 day 2 <input type="checkbox"/> 1 day to 1 week 3 <input type="checkbox"/> More than 1 week but within 30 days	1 <input type="checkbox"/> Less than 1 day 2 <input type="checkbox"/> 1 day to 1 week 3 <input type="checkbox"/> More than 1 week but within 30 days	1 <input type="checkbox"/> Less than 1 day 2 <input type="checkbox"/> 1 day to 1 week 3 <input type="checkbox"/> More than 1 week but within 30 days	1 <input type="checkbox"/> Less than 1 day 2 <input type="checkbox"/> 1 day to 1 week 3 <input type="checkbox"/> More than 1 week but within 30 days
1,000 cu. ft.	Barrels	Gallons	Barrels
1 <input type="checkbox"/> Less than 1 day 2 <input type="checkbox"/> 1 day to 1 week 3 <input type="checkbox"/> More than 1 week but within 30 days	1 <input type="checkbox"/> Less than 1 day 2 <input type="checkbox"/> 1 day to 1 week 3 <input type="checkbox"/> More than 1 week but within 30 days	1 <input type="checkbox"/> Less than 1 day 2 <input type="checkbox"/> 1 day to 1 week 3 <input type="checkbox"/> More than 1 week but within 30 days	1 <input type="checkbox"/> Less than 1 day 2 <input type="checkbox"/> 1 day to 1 week 3 <input type="checkbox"/> More than 1 week but within 30 days

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1988 Manufacturing Energy Consumption Survey Form EIA-846B (Continued)

Section IV — REMARKS — Please use this space or attach a separate sheet for any explanations that may be essential in understanding your reported data. Be sure to include the name, address, and telephone number of power generating establishments of your company that transferred or delivered electricity or steam to your establishment in 1988 if you did not have enough room in section I.

Section V — CERTIFICATION — The data in this report have been prepared in accordance with the instructions.

Name of person to contact regarding this report — <i>Print or type</i>		Area code	Number	Extension	
		Telephone			
Address — <i>Number and street</i>		Period covered by this report	FROM: Mo.	Day	Year
			TO: Mo.	Day	Year
City	State	ZIP Code	Signature of authorized person		Date

FORM EIA-846B (5-1-88)

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1988 Manufacturing Energy Consumption Survey

Form EIA-846B (Continued)

EIA-846B-1
(5-7-89)

U.S. DEPARTMENT OF COMMERCE
BUREAU OF THE CENSUS

INSTRUCTIONS FOR FORM EIA-846B

Petroleum Refineries

1988 MANUFACTURING ENERGY CONSUMPTION SURVEY

A. Who Is Responsible for Conducting the Manufacturing Energy Consumption Survey?

The Manufacturing Energy Consumption Survey (MECS) was designed, and is being sponsored, by the Energy Information Administration (EIA) of the U.S. Department of Energy. The survey is being administered and compiled by the U.S. Bureau of the Census.

B. What Is The Purpose of This Survey?

The MECS will collect data on energy consumption and usage patterns for the manufacturing sector of the U.S. economy. In addition, it will measure the short-term (within 30 days) capability of your establishment to have used substitute fuels in place of those actually consumed in 1988. The information obtained from the MECS will be used to publish aggregate statistics on the consumption of energy for fuel and nonfuel uses, and on some energy-related issues such as energy prices, electricity generation onsite, and fuel-switching capabilities.

C. Who Should Report?

This survey is mandatory under the Federal Energy Administration Act of 1974, P.L. 93-275, and under Title 3, Subtitle B of the Omnibus Budget Reconciliation Act of 1986, Public Law 99-509.

This form is addressed to establishments operating petroleum refineries SIC 2911, as defined by the 1987 Standard Industrial Classification Manual (SIC). Establishments operating in the manufacturing sector, SIC 20 through 28, the remainder of SIC 29, and SIC 30 through 39 will complete similar MECS forms. Response by establishments included in the MECS sample selected for the survey and receiving the MECS survey form is required by law. Failure to respond may result in criminal fines, civil penalties, and other sanctions as provided by law.

D. How Is My Privacy Protected?

By Section 9 of Title 13, U.S. Code, your report to the Census Bureau is confidential. It may be seen only by sworn Census Bureau employees and may be used only for statistical purposes. The law also provides that copies retained in your files are immune from legal process.

E. When Is The Report Due?

The questionnaire should be returned by the due date specified on the form. Please use the enclosed return envelope. If the envelope has been misplaced, return the completed questionnaire to:

Bureau of the Census
1201 East Tenth Street
Jeffersonville, IN 47132

F. How Is a Manufacturing Establishment Defined?

A manufacturing establishment is an economic unit at a single physical location where the mechanical or chemical transformation of materials or substances into new products is performed. These operations are generally conducted in facilities described as plants, factories, or mills and characteristically use power-driven machines and material-handling equipment. Manufacturing also includes such activities as the assembly of components of manufactured products and the blending of materials such as lubricating oil, plastics, resins, or liquors.

An establishment is not necessarily identical to a business concern or firm, either of which may consist of one or more establishments. An establishment may consist of one or more units that

are engaged in separate or distinct activities. These units may be separated physically as well as economically, with separate records or substantially accurate reports available for each. If this establishment has previously completed the Annual Survey of Manufactures (ASM), Form MA-1000, conducted by the U.S. Census Bureau, establishment boundaries should correspond to those used for the ASM. Each unit should be treated as a separate establishment ONLY if that was the determination made for the ASM. Do not consolidate two ASM establishments into a single establishment for purposes of the MECS, or separate a single ASM establishment into two MECS establishments. Match the 11-digit Census File Number (CFN) located on the MECS questionnaire mailing label with the CFN on the ASM mailing label. Responses to MECS questions should include the same activities as those considered when responding to the matching ASM. If this establishment has never completed an ASM, report for all activities that occur at this physical location.

Section 1 -- NONCOMBUSTIBLE ENERGY SOURCES

Energy sources used in manufacturing can be divided into two groups: combustible (capable of being burned), and noncombustible (such as electricity, steam, and industrial hot water). The purpose of section 1 is to collect 1988 data for noncombustible energy sources, in particular, electricity and steam.

Column 2 collects data that will provide important information on the components of electricity production, and permit an estimate to be made of the total consumption of electricity at your establishment. Column 3 collects data on the additional contribution that steam makes to the total consumption of energy at your establishment through net transfers and steam generated onsite by renewable energy sources. Column 4 collects data on hot water purchased for use as an energy source and used at this establishment site.

Electricity is to be reported in thousands of kilowatt-hours. Steam and industrial hot water are to be reported in millions of Btu. If you keep your records for steam in pounds, use a factor of 1,200 Btu per pound of steam to convert your data into Btu.

SPECIFIC INSTRUCTIONS

Line 1a -- Quantity Purchased From Utilities --

Enter the quantity of each noncombustible energy source that was purchased from a utility and delivered to this establishment site in 1988, regardless of when payment was made. For purposes of this question, utilities are companies that produce and/or deliver electricity and/or natural gas, and are legally obligated to provide service to the general public within their franchise area. Utilities do not include such generators of electricity as independent power producers, small power producers, or cogenerators not located at this establishment site. Include quantities purchased for ANY onsite use, for example, production of heat and power, electrolysis processes, or steam cleaning. Exclude all:

- quantities purchased from independent power producers, small power producers, or cogenerators not located at this establishment site.
- quantities delivered from other establishments in your company even if those quantities were repurchased from them by your establishment.
- quantities purchased and paid for by a central purchasing entity separate from this establishment.
- quantities for which payment was made in-kind.

CONTINUE ON PAGE 2

1988 Manufacturing Energy Consumption Survey

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Page 2

Line 1b — Expenditures For Purchases From Utilities — Enter the total expenditures for the purchased quantities reported on line 1a. Include all expenditures regardless of when payment was actually made.

Line 2a — Quantity Purchased From Nonutilities — Enter the quantity of electricity and steam that was purchased from offsite nonutility power producers and delivered to this establishment site in 1988, regardless of when payment was made. Include quantities purchased for **ANY** onsite use.
Exclude all:

- quantities delivered from other establishments in your company even if those quantities were repurchased from them by your establishment.
- quantities purchased and paid for by a central purchasing entity separate from this establishment.
- quantities for which payment was made in-kind.

Line 2b — Expenditures For Purchases From Nonutilities — Enter the total expenditures for the purchased quantities reported on line 2a. Include all expenditures regardless of when payment was actually made.

Line 3 — Other Receipts — Enter all additional quantities delivered to your establishment site in 1988 but not reported on lines 1a or 2a.
Include:

- quantities purchased and paid for by a central purchasing entity separate from this establishment.
- quantities transferred from another establishment of your company for which payment was not made.
- quantities delivered from another establishment of your company even if those quantities were repurchased from them by your establishment.
- quantities for which payment was made in-kind.

Line 4 — Total Electricity Receipts — Enter the sum of lines 1a, 2a and 3 for electricity only. Copy this total electricity receipt figure to column 2, line 1 of Section III — Fuel Switching.

Line 5 — Quantity Cogenerated — Enter the total quantity of electricity cogenerated from all energy sources, including renewable sources. For purposes of this survey, electrical cogeneration is defined as the production of electric energy and another form of useful energy (such as heat or steam) through the sequential use of energy.

Line 6 — Quantity Generated from Renewables — Enter the total quantity of each noncombustible energy source generated onsite directly from solar power, wind power, hydropower, or geothermal sources. Any electricity produced as a part of a cogeneration process (that is, electricity generated from geothermal steam which is then itself used) should be excluded. Such quantities should be included on line 5.

Line 7 — Other Generation — Enter the total quantity of electricity generated onsite by all other means not included on lines 5 and 6 above. For example, electricity generated by diesel generators should be reported here.

Line 8 — Sales or Transfers to Utilities — Enter the total quantity of electricity sold or transferred by your establishment in 1988 to utilities. For purposes of this survey, utilities are companies that produce and/or deliver electricity and/or natural gas, and are legally obligated to provide service to the general public within their franchise area. Utilities do not include such generators of electricity as independent power producers, small power producers, or cogenerators not located at this establishment site. Include quantities exchanged for the same or any other energy source(s).

Line 9 — Sales or Transfers to Nonutilities — Enter the total quantity of each noncombustible energy source sold or transferred in 1988 to establishments other than utilities. Include quantities exchanged for the same or any other energy source(s).

Line 10 — Nonutility Suppliers — If any electricity reported in column 2, line 3 was obtained by transfer from another establishment of your company, enter the name, address and telephone number of the supplying establishment. If you received transfers from more than one of this type of establishment, use the "Remarks" section to identify remaining suppliers.

Questions 11 and 12 should be completed if there was any electricity generated at this establishment site in 1988 (column 2 has a nonzero entry on lines 5, 6, or 7). If your establishment had no onsite generation in 1988, omit questions 11 and 12 and proceed with Section II — Combustible Energy Sources.

Question 11 — Indicate by checking the appropriate box whether or not this establishment was electrically interconnected with an electric utility (that is, able to deliver electricity to the grid as well as receive electricity) as of December 31, 1988.

Question 12 — Indicate by checking the appropriate box whether or not this establishment was designated as a Qualifying Facility (QF) under the Public Utility Regulatory Policies Act of 1978 (PURPA) as of December 31, 1988.

Section II — COMBUSTIBLE ENERGY SOURCES

There are two versions of Section II — Combustible Energy Sources. In order to determine which version you should complete, first determine whether your establishment consists only of a refinery, only of a petrochemical operation, or some combination of the two. For purposes of this survey, a refinery is an installation that manufactures finished petroleum products from crude oil, unfinished oils, natural gas liquids, other hydrocarbons, and alcohol. Processes used by a refinery include fractional distillation, cracking (both catalytic and hydrocracking), coking, reforming, alkylation, isomerization, polymerization, hydrotreating and sweetening. Products include, but are not limited to, unfinished oils, motor gasoline, aviation gasoline, special naphthas, kerosene, distillate fuel oil, residual fuel oil, lubricating oils, asphalt and road oil, waxes, petroleum coke, still gas and petrochemical feedstocks. A petrochemical operation produces substances by the chemical treatment of raw materials derived from petroleum or natural gas. Among the final products are plastics (including synthetic rubbers), synthetic fibers, chemicals, drugs, and detergents.

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Second, determine what establishment boundaries were used when completing the 1988 Annual Survey of Manufactures. Check the box next to the correct description of the manufacturing site that contains the establishment identified on the address label. Opposite each box is the schedule of Section II that should be completed.

- If the establishment site contains refinery operations **only**, complete version A of Section II **omitting** columns 9 and 10. (If the site contains both refinery and adjacent petrochemical operations that are identified as **separate establishments** for purposes of the ASM, version A of Section II should be completed, **omitting** columns 9 and 10.)
- If the establishment site contains both refinery and petrochemical operations that are identified as a **single establishment** for purposes of the ASM, complete ALL unshaded areas of version A.
- If the establishment site contains petrochemical operations **only**, complete version B of Section II. (If the site contains both petrochemical and refinery operations that are identified as **separate establishments** for purposes of the ASM, complete version B of Section II.)

VERSION A — SECTION II — COMBUSTIBLE ENERGY SOURCES

Column 1 — Energy Sources to be Reported — Sixteen energy sources have been preprinted in column 1, separated into the general categories of petroleum and nonpetroleum based. Determine from the criteria below which of the preprinted energy sources should be included for reporting and which excluded.

First, **EXCLUDE** all energy sources that were not consumed for any purpose at this establishment site during 1988. All excluded energy sources should be lined out, and no entries should be made in any column. Next, if your establishment consumed any energy sources for any purpose during 1988 that are not included in the preprinted list, add those energy sources under the "Other" heading for petroleum based or nonpetroleum based energy sources. **NOTE** — In making additional entries, the preprinted entry "Waste and byproduct gases" includes all waste gas streams (for example, refinery gas, fuel gas, vent gas, offgas, still gas, and other waste gases) produced onsite except hydrogen.

All unlined energy sources, including any additions to the preprinted list, should be further evaluated for inclusion or exclusion by the specific criterion listed below.

If your only means of supply of an energy source during 1988 was as a byproduct of energy source inputs to any of your manufacturing processes, it should be included **ONLY** if it was at least partially consumed onsite as a fuel during 1988 (that is for heat, power, or electricity generation). If none of that onsite-produced energy source was consumed onsite as a fuel, it should be excluded.

Complete the appropriate columns for all energy sources that were not excluded by the above procedures. Entries should be made in accordance with the specific instructions for these columns.

Column 3 — Reporting Units — Use the indicated units for reporting all quantities. For those establishments that keep records in Btu, note that volume measures should be reported as actual physical quantities, rather than adjusted to represent a standard energy content. One barrel contains 42 gallons. The approximate liquid equivalent conversion factor of LPG is 3.603 million Btu per barrel. Petroleum coke should also be reported in barrels. A barrel will hold approximately 400 pounds of petroleum coke, or the equivalent of 6.024 million Btu. A short ton of petroleum coke contains approximately 30.12 million Btu. Natural gas should be reported in thousands of cubic feet. One thousand cubic feet of natural gas is equal to about 10.3 therms, or 1.03 million Btu.

Column 4 — Quantity Purchased — Complete for nonpetroleum based energy sources only. Enter the quantity of each energy source that was purchased and delivered to this establishment in 1988, regardless of when payment was made. Include quantities of those energy sources that were purchased for **ANY** onsite use, for example, the production of heat or power, electrolysis processes, steam cleaning, or as a petrochemical feedstock or a raw material input to any manufacturing operation. **Exclude** all:

- quantities delivered from another establishment in your company even if those quantities were repurchased from them by your establishment.
- quantities purchased and paid for by a central purchasing entity separate from this establishment.
- quantities for which payment was made in-kind.

Column 5 — Expenditures — Complete for nonpetroleum based energy sources only. Enter the total expenditures for each of the purchased quantities reported in column 4. Include all expenditures regardless of when payment was made.

Column 6 — Other Receipts — Complete for nonpetroleum based energy sources only. For each included energy source, enter all additional quantities delivered to your establishment site in 1988 but not reported in column 4. **Include:**

- quantities purchased and paid for by a central purchasing entity separate from this establishment.
- quantities transferred from another establishment of your company for which payment was not made.
- quantities delivered from another establishment of your company even if these quantities were repurchased from them by your establishment.
- quantities for which payment was made in-kind.

Exclude any quantities transferred between a petroleum refinery and a chemical plant if the two were treated as a single establishment by the ASM.

Column 7 — Onsite Production — Complete for nonpetroleum based energy sources only. Enter the total quantity of any energy source that was produced onsite in 1988 as a product, a byproduct, a waste material, or an output from a captive (onsite) mine or well, and was at least partially consumed onsite. Enter the **TOTAL** quantity produced onsite, regardless of whether some or all of it was consumed as a fuel or feedstock, transferred offsite, sold, or otherwise disposed of. Examples of byproducts include petroleum coke, hydrogen, and still gas. Examples of waste products include wood scraps, packing materials, waste paper and cardboard, and waste oils.

1988 Manufacturing Energy Consumption Survey

Form EIA-846B (Continued)

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Column 8 — Onsite Fuel Consumption —

Complete for ALL energy sources. Enter the quantity consumed onsite as a fuel for the production of heat, steam, power, or the generation of electricity. Also include fuel consumed by vehicles dedicated primarily for use onsite. Copy the entries, if any, in Column 8 for natural gas, distillate fuel oil, residual fuel oil, LPG, and total coal products to line 1 of section III — Fuel Switching.

Column 9 — Onsite Nonfuel Consumption —

Complete ONLY if your establishment contains both refinery and non-refinery operations that are identified as a **single establishment** for purposes of the ASM. Note that this column requests data for the **NON-REFINERY** operations only. Enter the quantity of each energy source that was consumed onsite for all purposes other than fuel use. Include all quantities consumed as feedstocks (for example, butane processed in producing rubber compounds), raw materials (for example, coal used to produce coke), additives, or ingredients for products manufactured by this establishment. Exclude all offsite dispositions such as sales and transfers to other establishments.

Column 10 — Shipments Offsite to Other Establishments —

Complete ONLY if your establishment contains both refinery and non-refinery operations that are identified as a **single establishment** for purposes of the ASM. Note that this column requests data for the **NON-REFINERY** operations only. Enter the quantity of each energy source that was shipped offsite to any other establishment.

VERSION B — SECTION II — COMBUSTIBLE ENERGY SOURCES

Column 1 — Energy Sources to be Reported —

Twenty-three energy sources have been preprinted in column 1, separated into the general categories of solids, gases, and liquids. Determine from the criteria below which of the preprinted energy sources should be included for reporting and which excluded.

First, EXCLUDE all energy sources that were not consumed for any purpose at this establishment site during 1988. All excluded energy sources should be lined out, and no entries should be made in any column. Next, if your establishment consumed any energy sources for any purpose during 1988 that are not included in the preprinted list, add those energy sources under the "Other" heading for solids, gases, and liquids. NOTE — In making additional entries, the preprinted entry "Waste and byproduct gases" includes all waste gas streams (for example, refinery gas, fuel gas, vent gas, offgas, still gas, and other waste gases) produced onsite except hydrogen.

All unlined energy sources, including any additions to the preprinted list, should be further evaluated for inclusion or exclusion by the specific criterion listed below.

If your only means of supply of an energy source during 1988 was as a byproduct of energy source inputs to any of your manufacturing processes, it should be included ONLY if it was at least partially consumed onsite as a fuel during 1988 (that is for heat, power, or electricity generation). If none of that onsite-produced energy source was consumed onsite as a fuel, it should be excluded.

Complete the appropriate columns for all energy sources that were not excluded by the above procedures. Entries should be made in accordance with the specific instructions for these columns.

Column 3 — Reporting Units —

Use the indicated units for reporting all quantities. For those establishments that keep records in Btu, note that volume measures should be reported as actual physical quantities, rather than adjusted to represent a standard energy content. One barrel contains 42 gallons. The approximate liquid equivalent conversion factor of LPG is 3.603 million Btu per barrel. Petroleum coke should also be reported in barrels. A barrel will hold approximately 400 pounds of petroleum coke, or the equivalent of 6.024 million Btu. A short ton of petroleum coke contains approximately 30.12 million Btu. Natural gas should be reported in thousands of cubic feet. One thousand cubic feet of natural gas is equal to about 10.3 therms, or 1.03 million Btu.

Column 4 — Quantity Purchased — Enter the quantity of each energy source that was purchased and delivered to this establishment in 1988, regardless of when payment was made. Include quantities of those energy sources that were purchased for ANY onsite use, for example, the production of heat or power, electrolysis processes, steam cleaning, or as a petrochemical feedstock or a raw material input to any manufacturing operation. Exclude all:

- quantities delivered from another establishment in your company even if those quantities were repurchased from them by your establishment.
- quantities purchased and paid for by a central purchasing entity separate from this establishment.
- quantities for which payment was made in-kind.

Column 5 — Expenditures — Enter the total expenditures for each of the purchased quantities reported in column 4. Include all expenditures regardless of when payment was made.

Column 6 — Other Receipts — For each included energy source, enter all additional quantities delivered to your establishment site in 1988 but not reported in column 4. Include:

- quantities purchased and paid for by a central purchasing entity separate from this establishment.
- quantities transferred from another establishment of your company for which payment was not made.
- quantities delivered from another establishment of your company even if these quantities were repurchased from them by your establishment.
- quantities for which payment was made in-kind.

Exclude any quantities transferred between a petroleum refinery and a chemical plant if the two were treated as a **single establishment** by the ASM.

Column 7 — Onsite Production — Enter the total quantity of any energy source that was produced onsite in 1988 as a product, a byproduct, a waste material, or an output from a captive (onsite) mine or well, and was at least partially consumed onsite. Enter the TOTAL quantity produced onsite, regardless of whether some or all of it was consumed as a fuel or feedstock, transferred offsite, sold, or otherwise disposed of. Examples of byproducts include petroleum coke, hydrogen, and still gas. Examples of waste products include wood scraps, packing materials, waste paper and cardboard, and waste oils.

1988 Manufacturing Energy Consumption Survey Form EIA-846B (Continued)

Page 5

Column 8 — Source of Onsite Production — For each energy source that has an entry in column 7, check the "Yes" box if the amount listed in column 7 resulted from consumption of any other energy source listed in Section II — Combustible Energy Sources. Check the "No" box if the energy source came from captive wells or mines, or is a product or byproduct/waste product from materials not listed in Section II as a combustible energy source. Examples include:

- hydrogen produced as a byproduct of natural gas in an ammonia plant would have the "Yes" box checked.
- hydrogen produced through the electrolysis of brine in a chlorine plant would have the "No" box checked.
- coke oven gas produced during the coal coking process would have the "Yes" box checked.
- wood chips produced as a byproduct of wood purchased for use as a raw material rather than a fuel would have the "No" box checked.
- pulping (black) liquor, used in the chemical pulping of wood, that is burned in a recovery furnace or otherwise combusted, would have the "No" box checked.

Column 9 — Onsite Fuel Consumption — Enter the quantity consumed onsite as a fuel for the production of heat, steam, power, or the generation of electricity. Also include fuel consumed by vehicles dedicated primarily for use onsite. Copy the entries, if any, in column 9 for natural gas, distillate fuel oil, residual fuel oil, LPG, and total coal products to line 1 of Section III — Fuel Switching.

Column 10 — Onsite Nonfuel Consumption — Enter the quantity of each energy source that was consumed onsite for all purposes other than fuel use. Include all quantities consumed as feedstocks (for example, butane processed in producing rubber compounds), raw materials (for example, coal used to produce coke), additives, or ingredients for products manufactured by this establishment. Exclude all offsite dispositions such as sales and transfers to other establishments.

Supplemental Questions —

For the purposes of Questions 1, 2a, and 2b, energy sources and their approximate Btu conversion factors include:

Acetylene	21,500 Btu/lb
Breeze	19.8 million Btu/short ton
Butane	21,308 Btu/lb
Butylene	20,787 Btu/lb
Coal Coke	24.8 million Btu/short ton
Distillate fuel oil	5.825 million Btu/barrel
Ethane	22,320 Btu/lb
Ethylene	21,644 Btu/lb
Isobutane	21,257 Btu/lb
Petroleum coke	8,024 million Btu/barrel
Propane	21,661 Btu/lb
Propylene	21,041 Btu/lb
Residual fuel oil	6.287 million Btu/barrel

NOTE — If your establishment uses more precise conversion values for your operations, use them in place of the approximations given above.

Question 1 — Enter the total Btu content of all energy source products shipped offsite during 1988.

If the answer to question 1 is zero, omit question 2, parts a and b, and proceed directly to question 3. If question 1 has a non-zero response, include in the response to question 2 only those energy source products that were reported in question 1.

Question 2a — Enter the total Btu value of all energy source inventories as of December 31, 1987.

Question 2b — Enter the total Btu value of all energy source inventories as of December 31, 1988.

Question 3 — Enter the total design storage capacity located onsite as of December 31, 1988, for residual fuel oil, distillate fuel oil, and LPG. Report the shell capacity (that is, the design capacity of the storage tanks) in the units of measure specified. Include:

- onsite capacity of all storage facilities regardless of the intended disposition of the energy source (include both product storage tanks and tanks dedicated for onsite use).
- onsite capacity dedicated or leased for storage of energy sources owned by other establishments.

Section III — FUEL SWITCHING

This portion of the survey is intended to measure the short-term capability of your establishment to have used substitute energy sources in place of those actually consumed in 1988. Capability to use substitute energy sources means that this establishment's combustors (for example, boilers, furnaces, ovens, blast furnaces) had the machinery or equipment either in place or available for installation in 1988 so that substitutions could actually have been introduced within 30 days without extensive modifications.

NOTE — Fuel-switching capability as measured by this survey does not depend on the relative prices of energy sources. It depends only on the characteristics of your equipment and certain legal constraints. Fuel-switching capability sets limits on the extent to which you could switch to a substitute energy source if you wanted to or needed to. It has nothing to do with whether you would want to switch if you could. Therefore, relative prices of energy sources are not related to fuel-switching CAPABILITY and should be ignored when completing this section.

We recognize that records of fuel-switching capability are not regularly maintained. Accordingly, reasonable approximations of fuel-switching capability are acceptable. These approximations should be based on the judgment of a person knowledgeable about the fuel-switching capability and operations of your establishment. They are not expected to be formal engineering estimates based on a day-by-day analysis of the operating levels of individual combustors and interactions between them. Respond as realistically as possible, given your actual operations in 1988.

Base your estimates on the availability of substitute energy sources and the physical condition of your equipment during 1988. Include switching capability that could have resulted from the use of redundant and/or standby combustors, and from combustors that were already equipped to fire alternative fuels. Lines 1 through 3 of this portion of the form measure your establishment's overall capability to have switched from specific energy sources in 1988. Lines 4a through 10b describe your capability to replace a given energy source by specific alternative energy sources.

1988 Manufacturing Energy Consumption Survey

Form EIA-846B (Continued)

Page 6

Specific Instructions

Line 1 — Quantity Consumed — Enter the total electricity receipts figure from line 4 of Section I, and the fuel consumption figures from Section II for total coal and coke, natural gas, distillate fuel oil, LPG, and residual fuel oil. The quantities to be copied are noted in the appropriate boxes of Sections I and II.

Line 2 — Quantity Nonswitchable — Enter the amount of the quantity reported on Line 1 that could NOT have been replaced within 30 days by any other energy source in 1988, even given a severe curtailment. NOTE — Include only that portion of total electricity receipts (purchases plus transfers in) that could NOT have been replaced by either onsite-generated electricity or energy source(s) which accomplish the same purposes as the offsite-produced electricity (e.g., supplying heat or power). Portions of individual fuels may be non-switchable due to limitations such as:

- the characteristics of your physical plant (for example, single-fired combustors or the absence of redundant and/or standby combustors), or the requirements of your manufacturing process.
- binding take or pay contracts with energy suppliers that were in place.
- environmental regulations which limit the amounts of potential replacement fuels that could be burned.

DO NOT consider current relative prices of fuels as a limitation to switching capability.

Line 3 — Quantity Switchable — Subtract line 2 from line 1 and enter the results. These values represent the quantity of each energy source consumed that COULD HAVE BEEN replaced within 30 days by at least one other energy source in 1988. NOTE — If all entries on line 3 are zero, complete the Comments and Certification sections of the survey and return it to the Census Bureau. For each entry on line 3 that is non-zero, complete the remainder of that column. Complete one column before starting another.

Lines 4 through 10, Part a — Replacement Quantities — Report the maximum amount of the quantity shown on line 3 that could have been replaced within 30 days by each of the energy sources on lines 4 through 10, under the constraints listed in the instructions for line 2. Report all amounts in the units of the energy source that is being replaced. DO NOT convert this amount to units of the replacement energy sources. NOTE — Be sure to take into account not only the fuels that could be directly substituted for offsite-produced electricity, but also the fuels needed to generate electricity onsite that could have been used in place of electricity receipts.

NOTE — The sum of lines 4a through 10a for each column must be at least as large as the entry on line 3 of that column, and may be larger if more than one alternative fuel could have been used.

Lines 4 through 10, Part b — Lead Time — Mark the minimum lead time required to switch to each replacement energy source identified.

Section IV — REMARKS

Please provide any explanations that may be helpful to us in understanding your reported data. Attach a separate sheet if necessary. Be sure to include the name, address, and telephone number of nonutility power generating establishments of your company that supplied electricity to your establishment if you did not have enough room in section I to identify them.

Section V — CERTIFICATION

Period Covered By This Report — Enter the month, day, and year of the beginning and the end of the period covered by your report. If a calendar year report: "From January 1 to December 31, 1988,"; if a fiscal year, specify which (such as "From December 1, 1987 to November 30, 1988"). If a part-year report is submitted because the establishment was not in operation or under your company's control for the entire year, specify the actual period covered: for example "January 2, 1988 to August 15, 1988," or "June 1, 1988 to December 31, 1988."

1988 Manufacturing Energy Consumption Survey

Form EIA-846C

OMB No. 1905-0189; Approval Expires 04/30/91

FORM EIA-846C
(8-1-89)

U.S. DEPARTMENT OF COMMERCE
BUREAU OF THE CENSUS
ACTING AS COLLECTING AND COMPLYING AGENT FOR
UNITED STATES DEPARTMENT OF ENERGY
ENERGY INFORMATION ADMINISTRATION



Chemicals and Allied Products;
Steel Works, Blast Furnaces,
and Rolling Mills; Products of
Petroleum and Coal

1988 MANUFACTURING ENERGY CONSUMPTION SURVEY

NOTICE — This survey is mandatory under the Federal Energy Administration Act of 1974, P.L. 93-276, and under Title 3, Subtitle B of the Omnibus Budget Reconciliation Act of 1980, P.L. 96-509. Failure to respond may result in criminal fines, civil penalties, and other sanctions as provided by law. The confidentiality of your response to this survey is protected by law (title 13, U.S. Code). Your response may be seen only by sworn Census employees and may be used only for statistical purposes. The law also provides that copies retained in your files are exempt from legal process.

Public reporting burden for this collection of information is estimated to average 5 hours per response, including the time of reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to the Energy Information Administration, Office of Statistical Standards, E-73, Mail Station: 1H-023 Fernside, 1000 Independence Avenue, SW, Washington, DC 20486; and to the Office of Information and Regulatory Affairs, Office of Management and Budget, Washington, DC 20503.

In correspondence pertaining to this report, please refer to this Census File Number (CFN).

Please correct errors in name, address, and ZIP Code. ENTER street and number if not shown.

RELEASE COMPLETE DATA
FORM EIA-846C (8-1-89)

BUREAU OF THE CENSUS
1201 East Tenth Street
Jeffersonville, IN 47132

DUE DATE:

If you cannot file by the due date, a time extension request should be sent to the above address, please include your 11-digit Census File Number (CFN).

NOTE

Please read the enclosed instructions before filling out this form. Complete each item. If you have any questions, call (301) 763-7066.

Section I — NONCOMBUSTIBLE ENERGY SOURCES

Item description (1)	109 Electricity (2)	117 Steam (3)	125 Industrial hot water (4)
	Kilowatthours	Million Btu	Million Btu
1a. During 1988, what amount of each energy source was purchased by this establishment from outside and delivered to this establishment site?	Mil. Thou. kWh		
1b. What was the total expenditure for the purchased energy sources reported on line 1a?	Mil. Thou. Dol.	Mil. Thou. Dol.	Mil. Thou. Dol.
2a. During 1988, what amount of electricity and steam was purchased from nonutility suppliers by this establishment and delivered to this establishment site?	Mil. Thou. kWh	Million Btu	
2b. What was the total expenditure for the purchased electricity and steam reported on line 2a?	Mil. Thou. Dol.	Mil. Thou. Dol.	
3. During 1988, what amount of each energy source was transferred from outside establishments and delivered to this establishment site? Do not include the purchases reported in lines 1a or 2a.	Mil. Thou. kWh		Million Btu
4. TOTAL electricity receipts. (Sum of lines 1a, 2a, and 3). NOTE — Copy this quantity to column 2, line 1 of Section III — FUEL SWITCHING.			
5. During 1988, how much electricity was generated on this establishment site by cogeneration?		Million Btu	Million Btu
6. During 1988, how much of each energy source was generated onsite from solar power, wind power, hydropower, and geothermal sources?			
7. During 1988, how much electricity was generated onsite by processes other than those covered on lines 5 and 6?			
8. During 1988, how much electricity was sold or transferred to utilities?		Million Btu	Million Btu
9. During 1988, how much of each energy source was sold or transferred to establishments other than utilities?			
10. If line 3, column 2 has a nonzero entry, and any of your electricity suppliers was another establishment of your company, identify that establishment at right. If you received electricity transfers from more than one establishment of your company, provide their identifying information in the "Remarks" section.	1. Name of energy supplier Address — Number and street City State ZIP Code Phone number		
Questions 11 and 12 below should be answered if this establishment generated any electricity onsite in 1988. If no electricity was generated onsite (column 2 has zero entries for lines 5, 6, and 7), omit questions 11 and 12 and proceed directly to Section II — Combustible Energy Sources.			
11. Was this establishment electrically interconnected with an electric utility (that is, able to deliver electricity to the grid as well as receive electricity) as of December 31, 1988?	1 <input type="checkbox"/> Yes 2 <input type="checkbox"/> No		
12. Was this establishment designated as a Qualifying Facility (QF) under Public Utility Regulatory Policies Act of 1978 (PURPA) as of December 31, 1988?	1 <input type="checkbox"/> Yes 2 <input type="checkbox"/> No		

1988 Manufacturing Energy Consumption Survey Form EIA-846C (Continued)

Section II - COMBUSTIBLE ENERGY SOURCES							
Energy sources (1)	Census Use Only (2)	Units used for reporting quantities (3)	Energy sources received in 1988				Total other receipts (transfers in and central purchases) (8)
			Quantity purchased by and delivered to this establishment (4)	Total expenditure, including delivery charges, of the quantity in col. (4) (5)			
				Mil.	Thou.	Dol.	
A. SOLIDS							
1. Anthracite	406	Short tons					
2. Bituminous and subbituminous coal	414						
3. Breeze	448						
4. Coal coke	430						
5. Lignite	422						
6. Total coal and coke (Sum of anthracite, bituminous and subbituminous coal, breeze, coal coke and lignite)	455						
7. Biomass	901	Million Btu					
8. Petroleum coke	703	Barrels					
9. Roundwood (wood cut specifically for fuel use)	802	Million Btu					
10. Waste materials (wastepaper, packing materials, etc.)	729						
11. Wood chips, bark, and wood waste	810						
12. Other solids (Specify)	919						
	927						
B. GASES							
1. Natural gas	307	1,000 cu. ft.					
2. Acetylene	646	Million Btu					
3. Blast furnace gas	604						
4. Coke oven gas	612						
5. Hydrogen	638						
6. Waste and byproduct gases (e.g., refinery off gas, vent gas, plant gas, still gas)	820						
7. Other gases (Specify)	935						
	843						
C. LIQUIDS							
1. Distillate fuel oil (numbers 1, 2, and 4 fuel oils and diesel)	224	Barrels					
2. Kerosene	273	Gallons					
3. LPG (ethane, ethylene, propane, propylene, butane, butylene)	240						
4. Motor gasoline	232	Million Btu					
5. Pulp or black liquor	737	Barrels					
6. Residual fuel oil (numbers 5, 6, navy special, and bunker c)	216						
7. Waste oils and tars	711	Million Btu					
8. Other liquids (Specify)	850						
	868						

For the purposes of questions 1, 2a, and 2b below, energy sources include: acetylene, breeze, butane/butylene, coal coke, distillate fuel oil, ethane/ethylene, isobutane, petroleum coke, propane/propylene, and residual fuel oil.

1. Total Btu content of energy source products shipped during 1988. Million Btu

If the answer to question 1 is zero, omit questions 2a and 2b and proceed directly to question 3 on page 3.

If question 1 has a nonzero response, include in the answers to questions 2a and 2b only those energy source products that were reported in question 1.

2a. Total Btu value of all energy source inventories as of December 31, 1987. Million Btu

2b. Total Btu value of all energy source inventories as of December 31, 1988. Million Btu

FORM EIA-846C (5-1-89)

Page 2

1988 Manufacturing Energy Consumption Survey Form EIA-846C (Continued)

Please enter this establishment's 11-digit Census File Number

Section II - COMBUSTIBLE ENERGY SOURCES - Continued

Energy sources produced onsite in 1988		Energy sources consumed onsite in 1988		Energy sources (11)	Census Use Only (12)
Quantity produced onsite (7)	Does the entry in col. (7) represent the product or byproduct of another energy source consumed onsite? (8)	Quantity consumed as a fuel (9)	Quantity consumed for all nonfuel purposes (10)		
				A. SOLIDS	
				1. Anthracite	406
				2. Bituminous and subbituminous coal	414
1 <input type="checkbox"/> Yes 2 <input type="checkbox"/> No				3. Breeze	448
1 <input type="checkbox"/> Yes 2 <input type="checkbox"/> No				4. Coal coke	430
				5. Lignite	422
Copy to line 1 of section 3				6. Total coal and coke (Sum of anthracite, bituminous and subbituminous coal, breeze, coal coke and lignite)	455
1 <input type="checkbox"/> Yes 2 <input type="checkbox"/> No				7. Biomass	901
				8. Petroleum cokes	703
				9. Roundwood (wood cut specifically for fuel use)	802
1 <input type="checkbox"/> Yes 2 <input type="checkbox"/> No				10. Waste materials (wastepaper, packing materials, etc.)	728
1 <input type="checkbox"/> Yes 2 <input type="checkbox"/> No				11. Wood chips, bark, and wood waste	810
1 <input type="checkbox"/> Yes 2 <input type="checkbox"/> No				12. Other solids	919
Copy to line 1 of section 3					927
1 <input type="checkbox"/> Yes 2 <input type="checkbox"/> No				B. GASES	
1 <input type="checkbox"/> Yes 2 <input type="checkbox"/> No				1. Natural gas	307
1 <input type="checkbox"/> Yes 2 <input type="checkbox"/> No				2. Acetylene	646
1 <input type="checkbox"/> Yes 2 <input type="checkbox"/> No				3. Blast furnace gas	604
1 <input type="checkbox"/> Yes 2 <input type="checkbox"/> No				4. Coke oven gas	612
1 <input type="checkbox"/> Yes 2 <input type="checkbox"/> No				5. Hydrogen	638
1 <input type="checkbox"/> Yes 2 <input type="checkbox"/> No				6. Waste and byproduct gases (e.g., refinery off gas, vent gas, plant gas, still gas)	620
1 <input type="checkbox"/> Yes 2 <input type="checkbox"/> No				7. Other gases	935
1 <input type="checkbox"/> Yes 2 <input type="checkbox"/> No					943
Copy to line 1 of section 3				C. LIQUIDS	
1 <input type="checkbox"/> Yes 2 <input type="checkbox"/> No				1. Distillate fuel oil (numbers 1, 2, and 4 fuel oils and diesel)	224
1 <input type="checkbox"/> Yes 2 <input type="checkbox"/> No				2. Kerosene	273
Copy to line 1 of section 3				3. LPG (ethane, ethylene, propane, propylene, butane, butylene)	240
1 <input type="checkbox"/> Yes 2 <input type="checkbox"/> No				4. Motor gasoline	232
1 <input type="checkbox"/> Yes 2 <input type="checkbox"/> No				5. Pulping or black liquor	737
Copy to line 1 of section 3				6. Residual fuel oil (numbers 5, 6, navy special, and bunker c)	216
1 <input type="checkbox"/> Yes 2 <input type="checkbox"/> No				7. Waste oils and tars	711
1 <input type="checkbox"/> Yes 2 <input type="checkbox"/> No				8. Other liquids	950
1 <input type="checkbox"/> Yes 2 <input type="checkbox"/> No					968

8. Enter the total design storage capacity located onsite as of December 31, 1988 for:

8a. Distillate fuel oil 224 Barrels

8b. Residual fuel oil 216 Barrels

8c. LPG 240 Gallons

1988 Manufacturing Energy Consumption Survey

Form EIA-846C (Continued)

Section III — FUEL SWITCHING

Item description (1)	109	Electricity (2)	455	Total coal and coke (3)
		Kilowatthours		Short tons
1. Quantity consumed — Copy the total electricity receipts from line 4 of section I, and the quantities of coal and coke, natural gas, distillate fuel oil, LPG, and residual fuel oil consumed onsite as a fuel from column (9) of section II.				
<i>Now answer lines 2 and 3 as appropriate for the columns with nonzero entries in line 1. Do not consider differences in energy prices when estimating amounts.</i>		Kilowatthours		Short tons
2. Quantity nonswitchable — Enter the amount of the quantity in line 1 that could NOT have been replaced within 30 days by another energy source in 1988.				
3. Quantity switchable — Subtract line 2 from line 1 and enter the results. This represents the total quantity of energy consumption that COULD HAVE BEEN replaced within 30 days by one or more alternative energy sources in 1988.		Kilowatthours		Short tons
<i>Now answer lines 4a through 10b as appropriate for the columns with nonzero entries in line 3. Complete one column before starting another.</i>				Short tons
4a. Of the amount shown in line 3, what is the maximum amount that could have been replaced by electricity?				
4b. What is the minimum lead time required to make the switch to electricity?			<input type="checkbox"/> 1 Less than 1 day <input type="checkbox"/> 2 1 day to 1 week <input type="checkbox"/> 3 More than 1 week but within 30 days	
5a. Of the amount shown in line 3, what is the maximum amount that could have been replaced by coal and coke?		Kilowatthours		
5b. What is the minimum lead time required to make the switch to coal and coke?		<input type="checkbox"/> 1 Less than 1 day <input type="checkbox"/> 2 1 day to 1 week <input type="checkbox"/> 3 More than 1 week but within 30 days		
6a. Of the amount shown in line 3, what is the maximum amount that could have been replaced by natural gas?		Kilowatthours		Short tons
6b. What is the minimum lead time required to make the switch to natural gas?		<input type="checkbox"/> 1 Less than 1 day <input type="checkbox"/> 2 1 day to 1 week <input type="checkbox"/> 3 More than 1 week but within 30 days	<input type="checkbox"/> 1 Less than 1 day <input type="checkbox"/> 2 1 day to 1 week <input type="checkbox"/> 3 More than 1 week but within 30 days	
7a. Of the amount shown in line 3, what is the maximum amount that could have been replaced by distillate fuel oil?		Kilowatthours		Short tons
7b. What is the minimum lead time required to make the switch to distillate fuel oil?		<input type="checkbox"/> 1 Less than 1 day <input type="checkbox"/> 2 1 day to 1 week <input type="checkbox"/> 3 More than 1 week but within 30 days	<input type="checkbox"/> 1 Less than 1 day <input type="checkbox"/> 2 1 day to 1 week <input type="checkbox"/> 3 More than 1 week but within 30 days	
8a. Of the amount shown in line 3, what is the maximum amount that could have been replaced by LPG?		Kilowatthours		Short tons
8b. What is the minimum lead time required to make the switch to LPG?		<input type="checkbox"/> 1 Less than 1 day <input type="checkbox"/> 2 1 day to 1 week <input type="checkbox"/> 3 More than 1 week but within 30 days	<input type="checkbox"/> 1 Less than 1 day <input type="checkbox"/> 2 1 day to 1 week <input type="checkbox"/> 3 More than 1 week but within 30 days	
9a. Of the amount shown in line 3, what is the maximum amount that could have been replaced by residual fuel oil?		Kilowatthours		Short tons
9b. What is the minimum lead time required to make the switch to residual fuel oil?		<input type="checkbox"/> 1 Less than 1 day <input type="checkbox"/> 2 1 day to 1 week <input type="checkbox"/> 3 More than 1 week but within 30 days	<input type="checkbox"/> 1 Less than 1 day <input type="checkbox"/> 2 1 day to 1 week <input type="checkbox"/> 3 More than 1 week but within 30 days	
10a. Of the amount shown in line 3, what is the maximum amount that could have been replaced by any other energy source? <i>Identify that energy source.</i>		Kilowatthours		Short tons
10b. What is the minimum lead time required to make the switch to that energy source?		<input type="checkbox"/> 1 Less than 1 day <input type="checkbox"/> 2 1 day to 1 week <input type="checkbox"/> 3 More than 1 week but within 30 days	<input type="checkbox"/> 1 Less than 1 day <input type="checkbox"/> 2 1 day to 1 week <input type="checkbox"/> 3 More than 1 week but within 30 days	

1988 Manufacturing Energy Consumption Survey Form EIA-846C (Continued)

Section IV — REMARKS — Please use this space or attach a separate sheet for any explanations that may be essential in understanding your reported data. Be sure to include the name, address, and telephone number of power generating establishments of your company that transferred or delivered electricity or steam to your establishment in 1988 if you did not have enough room in section I.

Section V — CERTIFICATION — The data in this report have been prepared in accordance with the instructions.

Name of person to contact regarding this report — Print or type		Area code	Number	Extension		
Address — Number and street		Telephone				
City		FROM:		Mo.	Day	Year
		TO:		Mo.	Day	Year
State	ZIP Code	Signature of authorized person		Date		

1988 Manufacturing Energy Consumption Survey

Form EIA-846C (Continued)

EIA-846C-1
(5-12-88)

U.S. DEPARTMENT OF COMMERCE
BUREAU OF THE CENSUS

INSTRUCTIONS FOR FORM EIA-846C

Chemicals and Allied Products; Steel Works, Blast Furnaces, and Rolling Mills; Products of Petroleum and Coal

1988 MANUFACTURING ENERGY CONSUMPTION SURVEY

A. Who Is Responsible for Conducting the Manufacturing Energy Consumption Survey?

The Manufacturing Energy Consumption Survey (MECS) was designed, and is being sponsored, by the Energy Information Administration (EIA) of the U.S. Department of Energy. The survey is being administered and compiled by the U.S. Bureau of the Census.

B. What Is The Purpose of This Survey?

The MECS will collect data on energy consumption and usage patterns for the manufacturing sector of the U.S. economy. In addition, it will measure the short-term (within 30 days) capability of your establishment to have used substitute fuels in place of those actually consumed in 1988. The information obtained from the MECS will be used to publish aggregate statistics on the consumption of energy for fuel and nonfuel uses, and on some energy-related issues such as energy prices, electricity generation onsite, and fuel-switching capabilities.

C. Who Should Report?

This survey is mandatory under the Federal Energy Administration Act of 1974, P.L. 93-275, and under Title 3, Subtitle B of the Omnibus Budget Reconciliation Act of 1986, Public Law 99-509.

This form is addressed to establishments operating in SIC 28, 29 (except 2911), and 3312, as defined by the 1987 Standard Industrial Classification Manual (SIC). Establishments operating in the manufacturing sector, SIC 20 through 27, and 30 through 39 will complete similar MECS forms. Response by establishments included in the MECS sample selected for the survey and receiving the MECS survey form is required by law. Failure to respond may result in criminal fines, civil penalties, and other sanctions as provided by law.

D. How Is My Privacy Protected?

By Section 9 of Title 13, U.S. Code, your report to the Census Bureau is confidential. It may be seen only by sworn Census Bureau employees and may be used only for statistical purposes. The law also provides that copies retained in your files are immune from legal process.

E. When Is The Report Due?

The questionnaire should be returned by the due date specified on the form. Please use the enclosed return envelope. If the envelope has been misplaced, return the completed questionnaire to:

Bureau of the Census
1201 East Tenth Street
Jeffersonville, IN 47132

F. How Is a Manufacturing Establishment Defined?

A manufacturing establishment is an economic unit at a single physical location where the mechanical or chemical transformation of materials or substances into new products is performed. These operations are generally conducted in facilities described as plants, factories, or mills and characteristically use power-driven machines and material-handling equipment. Manufacturing also includes such activities as the assembly of components of manufactured products and the blending of materials such as lubricating oil, plastics, resins, or liquors.

An establishment is not necessarily identical to a business concern or firm, either of which may consist of one or more establishments. An establishment may consist of one or more units that

are engaged in separate or distinct activities. These units may be separated physically as well as economically, with separate records or substantially accurate reports available for each. If this establishment has previously completed the Annual Survey of Manufactures (ASM), Form MA-1000, conducted by the U.S. Census Bureau, establishment boundaries should correspond to those used for the ASM. **Each unit should be treated as a separate establishment ONLY if that was the determination made for the ASM. Do not consolidate two ASM establishments into a single establishment for purposes of the MECS, or separate a single ASM establishment into two MECS establishments.** Match the 11-digit Census File Number (CFN) located on the MECS questionnaire mailing label with the CFN on the ASM mailing label. Responses to MECS questions should include the same activities as those considered when responding to the matching ASM. If this establishment has never completed an ASM, report for all activities that occur at this physical location.

Section 1 - NONCOMBUSTIBLE ENERGY SOURCES

Energy sources used in manufacturing can be divided into two groups: combustible (capable of being burned), and noncombustible (such as electricity, steam, and industrial hot water). The purpose of section 1 is to collect 1988 data for noncombustible energy sources, in particular, electricity and steam.

Column 2 collects data that will provide important information on the components of electricity production, and permit an estimate to be made of the total consumption of electricity at your establishment. Column 3 collects data on the additional contribution that steam makes to the total consumption of energy at your establishment through net transfers and steam generated onsite by renewable energy sources. Column 4 collects data on hot water purchased for use as an energy source and used at this establishment site.

Electricity is to be reported in thousands of kilowatt-hours. Steam and industrial hot water are to be reported in millions of Btu. If you keep your records for steam in pounds, use a factor of 1,200 Btu per pound of steam to convert your data into Btu.

SPECIFIC INSTRUCTIONS

Line 1a - Quantity Purchased From Utilities -

Enter the quantity of each noncombustible energy source that was purchased from a utility and delivered to this establishment site in 1988, regardless of when payment was made. For purposes of this question, utilities are companies that produce and/or deliver electricity and/or natural gas, and are legally obligated to provide service to the general public within their franchise area. Utilities do not include such generators of electricity as independent power producers, small power producers, or cogenerators not located at this establishment site. Include quantities purchased for ANY onsite use, for example, production of heat and power, electrolysis processes, or steam cleaning. **Exclude all:**

- quantities purchased from independent power producers, small power producers, or cogenerators not located at this establishment site.
- quantities delivered from other establishments in your company even if those quantities were repurchased from them by your establishment.
- quantities purchased and paid for by a central purchasing entity separate from this establishment.
- quantities for which payment was made in-kind.

CONTINUE ON PAGE 2

1988 Manufacturing Energy Consumption Survey

Form EIA-846C (Continued)

Page 2

Line 1b — Expenditures For Purchases From Utilities — Enter the total expenditures for the purchased quantities reported on line 1a. Include all expenditures regardless of when payment was actually made.

Line 2a — Quantity Purchased From Nonutilities — Enter the quantity of electricity and steam that was purchased from offsite nonutility power producers and delivered to this establishment site in 1988, regardless of when payment was made. Include quantities purchased for **ANY** onsite use. **Exclude** all:

- quantities delivered from other establishments in your company even if those quantities were repurchased from them by your establishment.
- quantities purchased and paid for by a central purchasing entity separate from this establishment.
- quantities for which payment was made in-kind.

Line 2b — Expenditures For Purchases From Nonutilities — Enter the total expenditures for the purchased quantities reported on line 2a. Include all expenditures regardless of when payment was actually made.

Line 3 — Other Receipts — Enter all additional quantities delivered to your establishment site in 1988 but not reported on lines 1a or 2a. **Include:**

- quantities purchased and paid for by a central purchasing entity separate from this establishment.
- quantities transferred from another establishment of your company for which payment was not made.
- quantities delivered from another establishment of your company even if those quantities were repurchased from them by your establishment.
- quantities for which payment was made in-kind.

Line 4 — Total Electricity Receipts — Enter the sum of lines 1a, 2a, and 3 for electricity only. *Copy this total electricity receipt figure to column 2, line 1 of Section III — Fuel Switching.*

Line 5 — Quantity Cogenerated — Enter the total quantity of electricity cogenerated from all energy sources, including renewable sources. For purposes of this survey, electrical cogeneration is defined as the production of electric energy and another form of useful energy (such as heat or steam) through the sequential use of energy.

Line 6 — Quantity Generated from Renewables — Enter the total quantity of each noncombustible energy source generated onsite directly from solar power, wind power, hydropower, or geothermal sources. Any electricity produced as a part of a cogeneration process (that is, electricity generated from geothermal steam which is then itself used) should be excluded. Such quantities should be included on line 5.

Line 7 — Other Generation — Enter the total quantity of electricity generated onsite by all other means not included on lines 5 and 6 above. For example, electricity generated by diesel generators should be reported here.

Line 8 — Sales or Transfers to Utilities — Enter the total quantity of electricity sold or transferred by your establishment in 1988 to utilities. For purposes of this survey, utilities are companies that produce and/or deliver electricity and/or natural gas, and are legally obligated to provide service to the general public within their franchise area. Utilities do not include such generators of electricity as independent power producers, small power producers, or cogenerators not located at this establishment site. Include quantities exchanged for the same or any other energy source(s).

Line 9 — Sales or Transfers to Nonutilities — Enter the total quantity of each noncombustible energy source sold or transferred in 1988 to establishments other than utilities. Include quantities exchanged for the same or any other energy source(s).

Line 10 — Nonutility Suppliers — If any electricity reported in column 2, line 3 was obtained by transfer from another establishment of your company, enter the name, address and telephone number of the supplying establishment. If you received transfers from more than one of this type of establishment, use the "Remarks" section to identify remaining suppliers.

Questions 11 and 12 should be completed if there was any electricity generated at this establishment site in 1988 (column 2 has a nonzero entry on lines 5, 6, or 7). If your establishment had no onsite generation in 1988, omit questions 11 and 12 and proceed with Section II — Combustible Energy Sources.

Question 11 — Indicate by checking the appropriate box whether or not this establishment was electrically interconnected with an electric utility (that is, able to deliver electricity to the grid as well as receive electricity) as of December 31, 1988.

Question 12 — Indicate by checking the appropriate box whether or not this establishment was designated as a Qualifying Facility (QF) under the Public Utility Regulatory Policies Act of 1978 (PURPA) as of December 31, 1988.

Section II — COMBUSTIBLE ENERGY SOURCES

Column 1 — Energy Sources to be Reported — Twenty-three energy sources have been preprinted in column 1, separated into the general categories of solids, gases, and liquids. Prior to completing columns 4 through 10, determine from the criteria below which of the preprinted energy sources should be included for reporting and which excluded.

First, **EXCLUDE** all energy sources that were not consumed for any purpose at this establishment site during 1988. All excluded energy sources should be lined out, and no entries should be made in columns 4 through 10. Next, if your establishment consumed any energy sources for any purpose during 1988 that are not included in the preprinted list, add those energy sources under the "Other" heading for solids, gases, or liquids.

All unlined energy sources, including any additions to the preprinted list, should be further evaluated for inclusion or exclusion by the specific criterion listed below.

If your only means of supply of an energy source during 1988 was as a byproduct of energy source inputs to any of your manufacturing processes, it should be included **ONLY** if it was at least partially consumed onsite as a fuel during 1988 (that is for heat, power, or electricity generation). If none of that onsite-produced energy source was consumed onsite as a fuel, it should be excluded.

Complete columns 4 through 10 for all energy sources that were not excluded by the above procedures. Entries should be made in accordance with the specific instructions for these columns.

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Page 3

Column 3 — Reporting Units — Use the indicated units for reporting all quantities. For those establishments that keep records in Btu, note that volume measures should be reported as actual physical quantities, rather than adjusted to represent a standard energy content. One barrel contains 42 gallons. The approximate liquid equivalent conversion factor of LPG is 3.603 million Btu per barrel. Petroleum coke should also be reported in barrels. A barrel will hold approximately 400 pounds of petroleum coke, or the equivalent of 6.024 million Btu. A short ton of petroleum coke contains approximately 30.12 million Btu. Natural gas should be reported in thousands of cubic feet. One thousand cubic feet of natural gas is equal to about 10.3 therms, or 1.03 million Btu.

Column 4 — Quantity Purchased — Enter the quantity of each energy source that was purchased and delivered to this establishment in 1988, regardless of when payment was made. Include quantities of those energy sources that were purchased for ANY onsite use, for example, the production of heat or power, electrolysis processes, steam cleaning, or as a petrochemical feedstock or a raw material input to any manufacturing operation. **Exclude all:**

- quantities delivered from another establishment in your company even if those quantities were repurchased from them by your establishment.
- quantities purchased and paid for by a central purchasing entity separate from this establishment.
- quantities for which payment was made in-kind.

Column 5 — Expenditures — Enter the total expenditures for each of the purchased quantities reported in column 4. Include all expenditures regardless of when payment was made.

Column 6 — Other Receipts — For each included energy source, enter all additional quantities delivered to your establishment site in 1988 but not reported in column 4. **Include:**

- quantities purchased and paid for by a central purchasing entity separate from this establishment.
- quantities transferred from another establishment of your company for which payment was not made.
- quantities delivered from another establishment of your company even if these quantities were repurchased from them by your establishment.
- quantities for which payment was made in-kind.

Column 7 — Onsite Production — Enter the total quantity of any energy source that was produced onsite in 1988 as a product, a byproduct, a waste material, or an output from a captive (onsite) mine or well, and was at least partially consumed onsite. Enter the TOTAL quantity produced onsite, regardless of whether some or all of it was consumed as a fuel or feedstock, transferred offsite, sold, or otherwise disposed of. Examples of byproducts include coke, hydrogen, still gas, coke oven gas, wood chips and black liquor. Examples of waste products include wood scraps, packing materials, waste paper and cardboard, and waste oils.

Column 8 — Source of Onsite Production — For each energy source that has an entry in column 7, check the "Yes" box if the amount listed in column 7 resulted from consumption of any other energy source listed in Section II — Combustible Energy Sources. Check the "No" box if the energy source came from captive wells or mines, or is a product or byproduct/waste product from materials not listed in section II as a combustible energy source. Examples include:

- hydrogen produced as a byproduct of natural gas in an ammonia plant would have the "Yes" box checked.
- hydrogen produced through the electrolysis of brine in a chlorine plant would have the "No" box checked.
- coke oven gas produced during the coal coking process would have the "Yes" box checked.
- wood chips produced as a byproduct of wood purchased for use as a raw material rather than a fuel would have the "No" box checked.
- pulping (black) liquor, used in the chemical pulping of wood, that is burned in a recovery furnace or otherwise combusted, would have the "No" box checked.

Column 9 — Onsite Fuel Consumption — Enter the quantity consumed onsite as a fuel for the production of heat, steam, power, or the generation of electricity. Also include fuel consumed by vehicles dedicated primarily for use onsite. Copy the entries, if any, in column 9 for natural gas, distillate fuel oil, residual fuel oil, LPG, and total coal products to line 1 of Section III — Fuel Switching.

Column 10 — Onsite Nonfuel Consumption — Enter the quantity of each energy source that was consumed onsite for all purposes other than fuel use. Include all quantities consumed as feedstocks (for example, butane processed in producing rubber compounds), raw materials (for example, coal used to produce coke), additives, or ingredients for products manufactured by this establishment. Exclude all offsite dispositions such as sales and transfers to other establishments.

Supplemental Questions —

For the purposes of Questions 1, 2a, and 2b, energy sources and their approximate Btu conversion factors include:

Acetylene	21,500 Btu/lb
Breeze	19.8 million Btu/short ton
Butane	21,308 Btu/lb
Butylene	20,787 Btu/lb
Coal Coke	24.8 million Btu/short ton
Distillate fuel oil	5,825 million Btu/barrel
Ethane	22,320 Btu/lb
Ethylene	21,644 Btu/lb
Isobutane	21,267 Btu/lb
Petroleum coke	6,024 million Btu/barrel
Propane	21,661 Btu/lb
Propylene	21,041 Btu/lb
Residual fuel oil	6,287 million Btu/barrel

NOTE — If your establishment uses more precise conversion values for your operations, use them in place of the approximations given above.

1988 Manufacturing Energy Consumption Survey

Form EIA-846C (Continued)

Page 4

Question 1 — Enter the total Btu content of all energy source products shipped offsite during 1988.

If the answer to question 1 is zero, omit question 2, parts a and b, and proceed directly to question 3. If question 1 has a non-zero response, include in the response to question 2 only those energy source products that were reported in question 1.

Question 2a — Enter the total Btu value of all energy source inventories as of December 31, 1987.

Question 2b — Enter the total Btu value of all energy source inventories as of December 31, 1988.

Question 3 — Enter the total design storage capacity located onsite as of December 31, 1988, for residual fuel oil, distillate fuel oil, and LPG. Report the shell capacity (that is, the design capacity of the storage tanks) in the units of measure specified.

Include:

- onsite capacity of all storage facilities regardless of the intended disposition of the energy source (include both product storage tanks and tanks dedicated for onsite use).
- onsite capacity dedicated or leased for storage of energy sources owned by other establishments.

Section III — FUEL SWITCHING

This portion of the survey is intended to measure the short-term capability of your establishment to have used substitute energy sources in place of those actually consumed in 1988. Capability to use substitute energy sources means that this establishment's combustors (for example, boilers, furnaces, ovens, blast furnaces) had the machinery or equipment either in place or available for installation in 1988 so that substitutions could actually have been introduced within 30 days without extensive modifications.

NOTE — Fuel-switching capability as measured by this survey does not depend on the relative prices of energy sources; it depends only on the characteristics of your equipment and certain legal constraints. Fuel-switching capability sets limits on the extent to which you could switch to a substitute energy source if you wanted to or needed to. It has nothing to do with whether you would want to switch if you could. Therefore, relative prices of energy sources are not related to fuel-switching CAPABILITY and should be ignored when completing this section.

We recognize that records of fuel-switching capability are not regularly maintained. Accordingly, reasonable approximations of fuel-switching capability are acceptable. These approximations should be based on the judgment of a person knowledgeable about the fuel-switching capability and operations of your establishment. They are not expected to be formal engineering estimates based on a day-by-day analysis of the operating levels of individual combustors and interactions between them. Respond as realistically as possible, given your actual operations in 1988.

Base your estimates on the availability of substitute energy sources and the physical condition of your equipment during 1988. Include switching capability that could have resulted from the use of redundant and/or standby combustors, and from combustors that were already equipped to fire alternative fuels. Lines 1 through 3 of this portion of the form measure your establishment's overall capability to have switched from specific energy sources in 1988. Lines 4a through 10b describe your capability to replace a given energy source by specific alternative energy sources.

SPECIFIC INSTRUCTIONS

Line 1 — Quantity Consumed — Enter the total electricity receipts figure from column 2, line 4 of Section I, and the fuel consumption figures from Section II for total coal and coke, natural gas, distillate fuel oil, LPG, and residual fuel oil. The quantities to be copied are noted in the appropriate boxes of sections I and II.

Line 2 — Quantity Nonswitchable — Enter the amount of the quantity reported on Line 1 that could NOT have been replaced within 30 days by any other energy source in 1988, even given a severe curtailment. **NOTE** — Include only that portion of total electricity receipts (purchases plus transfers in) that could NOT have been replaced by either onsite-generated electricity or energy source(s) which accomplish the same purposes as the offsite-produced electricity (e.g. supplying heat or power). Portions of individual fuels may be non-switchable due to limitations such as:

- the characteristics of your physical plant (for example, single-fired combustors or the absence of redundant and/or standby combustors), or the requirements of your manufacturing process.
- binding take or pay contracts with energy suppliers that were in place.
- environmental regulations which limit the amounts of potential replacement fuels that could be burned.

DO NOT consider current relative prices of fuels as a limitation to switching capability.

Line 3 — Quantity Switchable — Subtract line 2 from line 1 and enter the results. These values represent the quantity of each energy source consumed that COULD HAVE BEEN replaced within 30 days by at least one other energy source in 1988. **NOTE** — If all entries on line 3 are zero, complete the Remarks and Certification sections of the survey and return it to the Census Bureau. For each entry on line 3 that is nonzero, complete the remainder of that column. Complete one column before starting another.

Lines 4 through 10, Part a — Replacement Quantities — Report the maximum amount of the quantity shown on Line 3 that could have been replaced within 30 days by each of the energy sources on lines 4 through 10, under the constraints listed in the instructions for line 2. Report all amounts in the units of the energy source that is being replaced. DO NOT convert this amount to units of the replacement energy sources. **NOTE** — Be sure to take into account not only the fuels that could be directly substituted for offsite-produced electricity, but also the fuels needed to generate electricity onsite that could have been used in place of electricity receipts.

NOTE — The sum of lines 4a through 10a for each column must be at least as large as the entry on line 3 of that column, and may be larger if more than one alternative fuel could have been used.

Lines 4 through 10, Part b — Lead Time — Mark the minimum lead time required to switch to each replacement energy source identified.

Section IV — REMARKS

Please provide any explanations that may be helpful to us in understanding your reported data. Attach a separate sheet if necessary. Be sure to include the name, address, and telephone number of nonutility power generating establishments of your company that supplied electricity to your establishment if you did not have enough room in section I to identify them.

Section V — CERTIFICATION

Period Covered By This Report — Enter the month, day, and year of the beginning and the end of the period covered by your report. If a calendar year report: "From January 1 to December 31, 1988,"; if a fiscal year, specify which (such as "From December 1, 1987 to November 30, 1988"). If a part-year report is submitted because the establishment was not in operation or under your company's control for the entire year, specify the actual period covered: for example "January 2, 1988 to August 15, 1988," or "June 1, 1988 to December 31, 1988."

Appendix E

Descriptions of Industry Groups and Selected Industries

Appendix E

Descriptions of Major Industrial Groups and Selected Industries

This appendix contains descriptions of industrial groups and selected industries taken from the *Standard Industrial Classification Manual, 1987* (SIC).⁵² This appendix includes descriptions of the 30 groups that comprise the strata of the Manufacturing Energy Consumption Survey. These are the 20 major industrial groups (2-digit SIC) and the 10 major energy-consuming industries (4-digit SIC). The Standard Industrial Classification system is described in Appendix A.

SIC 20—Food and Kindred Products: This major group includes establishments manufacturing foods and beverages for human consumption and certain related products such as manufactured ice, chewing gum, vegetable and animal fats and oils, and prepared feeds for animals and fowls.

SIC 21—Tobacco Products: This major group includes establishments engaged in manufacturing cigarettes, cigars, smoking and chewing tobacco, snuff, and reconstituted tobacco and in stemming and redrying tobacco.

SIC 22—Textile Mill Products: This major group includes establishments engaged in performing any of the following operations: (1) preparation of fiber and subsequent manufacturing of yarn, thread, braids, twine, and cordage; (2) manufacturing broadwoven fabrics, narrow woven fabrics, knit fabrics, and carpets and rugs from yarn; (3) dyeing and finishing fiber, yarn, fabrics, and knit apparel; (4) coating, waterproofing, or otherwise treating fabrics; (5) the integrated manufacture of knit apparel and other finished articles from yarn; and (6) the manufacture of felt goods, lace goods, nonwoven fabrics, and miscellaneous textiles.

SIC 23—Apparel and Other Textile Products: This major group, known as the cutting-up and needle trades, includes establishments producing clothing and fabricating products by cutting and sewing purchased woven or knit textile fabrics and related materials, such as leather, rubberized fabrics, plastics, and furs.

SIC 24—Lumber and Wood Products: This major group includes establishments engaged in cutting timber and pulpwood; merchant sawmills, lath mills, shingle mills, cooperage stock mills, planing mills, and plywood and veneer mills engaged in producing lumber and wood basic materials; and establishments engaged in manufacturing finished articles made entirely or mainly of wood or related materials.

SIC 25—Furniture and Fixtures: This major group includes establishments engaged in manufacturing household, office, public building, and restaurant furniture; and office and store fixtures.

SIC 26—Paper and Allied Products: This major group includes establishments primarily engaged in the manufacture of pulps from wood and other cellulose fibers, and from rags; the manufacture of paper and paper board; and the manufacture of paper and paperboard into converted products, such as paper coated off the paper machine, paper bags, paper boxes, and envelopes.

SIC 2621—Paper Mills: Establishments primarily engaged in manufacturing paper from wood pulp and other fiber pulp, and which may also manufacture converted paper products.

SIC 2631—Paperboard Mills: Establishments primarily engaged in manufacturing paperboard, including paperboard coated on the paperboard machine, from wood pulp and other fiber pulp.

⁵²Executive Office of the President, Office of Management and Budget, *Standard Industrial Classification Manual, 1987*, pp. 67-263.

SIC 27—Printing and Publishing: This major group includes establishments engaged in printing by one or more common processes, such as letterpress, lithography (including offset), gravure, or screen; and those establishments which perform services for the printing trade, such as bookbinding and platemaking.

SIC 28—Chemicals and Allied Products: This major group includes establishments producing basic chemicals, and establishments manufacturing products by predominantly chemical processes. Establishments classified in this major group manufacture three general classes of products: (1) basic chemicals, such as acids, alkalies, salts, and organic chemicals; (2) chemical products to be used in further manufacture, such as synthetic fibers, plastics materials, dry colors, and pigments; and (3) finished chemical products to be used for ultimate consumption, such as drugs, cosmetics, and soaps; or to be used as materials or supplies in other industries, such as paints, fertilizers, and explosives.

SIC 2819—Industrial Inorganic Chemicals, Not Elsewhere Classified: Establishments primarily engaged in manufacturing industrial organic chemicals, excluding alkalies and chlorine, industrial gases, and inorganic pigments.

SIC 2821—Plastics Materials and Resins: Establishments primarily engaged in manufacturing synthetic resins, plastics materials, and nonvulcanizable elastomers.

SIC 2869—Industrial Organic Chemicals, Not Elsewhere Classified: Establishments primarily engaged in manufacturing industrial organic chemicals, excluding gum and wood chemicals, and cyclic organic crudes and intermediates, and organic dyes and pigments.

SIC 2873—Nitrogenous Fertilizers: Establishments primarily engaged in manufacturing nitrogenous fertilizer materials or mixed fertilizers from nitrogenous materials produced in the same establishment.

SIC 29—Petroleum Refining and Related Industries: This major group includes establishments primarily engaged in petroleum refining, manufacturing paving and roofing materials, and compounding lubricating oils and greases from purchased materials.

SIC 2911—Petroleum Refining: Establishments primarily engaged in producing gasoline, kerosene, distillate fuel oils, residual fuel oils, and lubricants, through fractionation or straight distillation of crude oil, redistillation of unfinished petroleum derivatives, cracking or other processes.

SIC 30—Rubber and Miscellaneous Plastics Products: This major group includes establishments manufacturing products, not elsewhere classified, from plastics, resins, and from natural, synthetic, or reclaimed rubber, gutta percha, balata, or gutta siak.

SIC 31—Leather and Leather Products: This major group includes establishments engaged in tanning, currying, and finishing hides and skins, leather converters, and establishments manufacturing finished leather and artificial leather products and some similar products made of other materials.

SIC 32—Stone, Clay, Glass, and Concrete Products: This major group includes establishments manufacturing flat glass and other glass products, cement, structural clay products, pottery, concrete and gypsum products, cut stone, abrasive and asbestos products, and other products from materials taken principally from the earth in the form of stone, clay, and sand.

SIC 3241—Cement, Hydraulic: Establishments primarily engaged in manufacturing hydraulic cement, including portland, natural, masonry, and pozzolana cements.

SIC 33—Primary Metal Industries: This major group includes establishments engaged in smelting and refining ferrous and nonferrous metals from ore, pig, or scrap; in rolling, drawing, and alloying metals; in manufacturing castings and other basic metal products; and in manufacturing nails, spikes, and insulated wire and cable.

SIC 3312—Steel Works, Blast Furnaces (Including Coke Ovens), and Rolling Mills: Establishments primarily engaged in manufacturing hot metal, pig iron, and silvery pig iron from iron ore and iron and steel scrap; converting pig iron, scrap iron, and scrap steel into steel; and in hot-rolling iron and steel into basic shapes, such as plates, sheets, strips, rods, bars, and tubing.

SIC 3334—Primary Production of Aluminum: Establishments primarily engaged in producing aluminum from alumina and in refining aluminum by any process.

SIC 34—Fabricated Metal Products: This major group includes establishments engaged in fabricating ferrous and nonferrous metal products such as metal cans, tinware, handtools, cutlery, general hardware, nonelectric heating apparatus, fabricated structural metal products, metal forgings, metal stampings, ordnance (except vehicles and guided missiles), and a variety of metal and wire products, not elsewhere classified.

SIC 35—Industrial Machinery and Equipment: This major group includes establishments engaged in manufacturing industrial and commercial machinery and equipment and computers.

SIC 36—Electronic and Other Electric Equipment: This major group includes establishments engaged in manufacturing machinery, apparatus, and supplies for the generation, storage, transmission, transformation, and utilization of electrical energy.

SIC 37—Transportation Equipment: This major group includes establishments engaged in manufacturing equipment for transportation of passengers and cargo by land, air, and water.

SIC 38—Instruments and Related Products: This major group includes establishments engaged in manufacturing instruments (including professional and scientific) for measuring, testing, analyzing, and controlling, and their associated sensors and accessories; optical instruments and lenses; surveying and drafting instruments; hydrological, hydrographic, meteorological, and geophysical equipment; search, detection, navigation, and guidance systems and equipment; surgical, medical, and dental instruments, equipment and supplies; ophthalmic goods; photographic equipment and supplies; and watches and clocks.

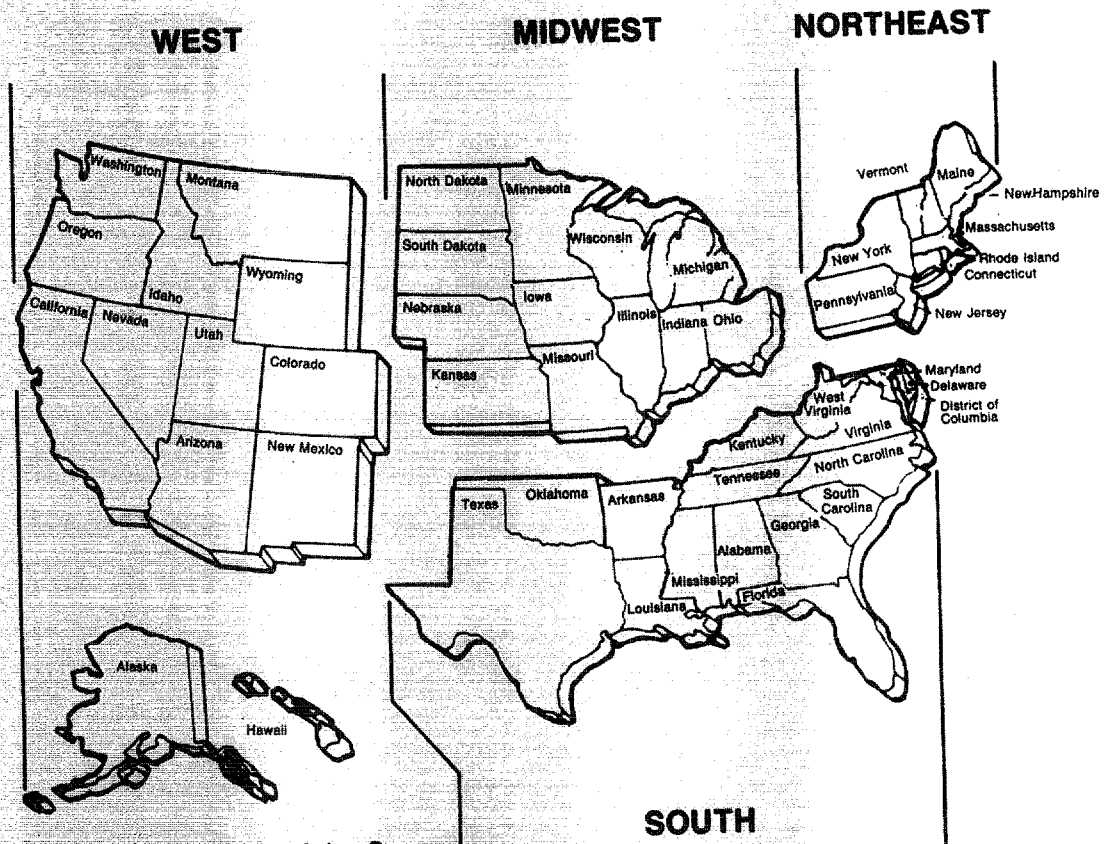
SIC 39—Miscellaneous Manufacturing Industries: This major group includes establishments primarily engaged in manufacturing products not classified in any other major group.

Appendix F

Map of U.S. Census Regions

Appendix F

Map of U.S. Census Regions



Source: U.S. Bureau of the Census

Appendix G

Related EIA Publications on Energy Consumption

Appendix G

Related EIA Publications on Energy Consumption

These publications are available from the National Energy Information Center or the Superintendent of Documents. See the inside cover of this report on how to obtain copies of these publications. Please note that the prices quoted are subject to change.

In addition to the reports listed below, public use data tapes and data diskettes for the residential, residential transportation and commercial sectors are available from the National Technical Information Service (NTIS). To obtain information on how to order the tapes/diskettes, you may call NTIS at 703/487-4807, FAX number 703/321-8547. Data diskettes can also be obtained from GPO. For ordering information call 220/275-0186.

Industrial Sector

Manufacturing Energy Consumption Survey: Consumption of Energy, 1988; May 1991, DOE/EIA-0512(88), GPO Stock No. 061-003-00703-8, \$11.00.

Manufacturing Energy Consumption Survey: Energy Efficiency in Manufacturing, 1985; January 1990, DOE/EIA-0516(85), GPO Stock No. 061-00300650-7, \$4.25.

Manufacturing Energy Consumption Survey: Fuel Switching Capability, 1985; December 1988, DOE/EIA-0515(85), GPO Stock No. 061-003-00601-9, \$3.50.

Manufacturing Energy Consumption Survey: Methodological Report, 1985; November 1988, DOE/EIA-0514(85), GPO Stock No. 061-00300595-1, \$6.00.

Manufacturing Energy Consumption Survey: Consumption of Energy, 1985; November 1988, DOE/EIA-0512(85), GPO Stock No. 061-003-00594-2, \$6.00.

"Manufacturing Sector Energy Consumption 1985 Provisional Estimates," Monthly Energy Review, January 1987, DOE/EIA-0035(87/01), pp. vii-x.

Report on the 1980 Manufacturing Industries' Energy Consumption Study and Survey of Large Combustors; February 1983, DOE/EIA-0358, GPO Stock No. 061-003-00293-5, \$5.00.

Industrial Energy Consumption, "Survey of Large Combustors: Report on Alternate Fuel-Burning Capabilities of Large Boilers in 1979"; February 1982, DOE/EIA-0304, GPO Stock No. 061-003-0233-1, \$2.50.

Methodological Report of the 1980 Manufacturing Industries Survey of Large Combustors (EIA-463); March 1982, DOE/EIA-0306 (no GPO Stock No.).

Commercial Sector

Note: The name of the Nonresidential Buildings Energy Consumption Survey was changed to the Commercial Buildings Energy Consumption Survey, beginning with the 1989 survey. The survey name was also dropped from the report title.

Characteristics of Buildings

Commercial Buildings Characteristics 1989; May 1991, DOE/EIA-0246(89), GPO Stock No. 061-003-00699-0, \$18.00.

Nonresidential Buildings Energy Consumption Survey: Characteristics of Commercial Buildings, 1986; September 1988, DOE/EIA-0246(86), GPO Stock No. 061-003-00580-2, \$16.00.

Nonresidential Buildings Energy Consumption Survey: Characteristics of Commercial Buildings, 1983; July 1985, DOE/EIA-0246(83), GPO Stock No. 061-003-00439-3, \$7.50.

Nonresidential Buildings Energy Consumption Survey: Characteristics of Commercial Buildings, 1983; A Supplemental Reference, DOE/EIA-M008, \$22.95. Available from the NTIS, Order No. DE-85015581.

Nonresidential Buildings Energy Consumption Survey: Fuel Characteristics and Conservation Practices; June 1981, DOE/EIA-0278, GPO Stock No. 061-00300200-5, \$9.00.

Nonresidential Buildings Energy Consumption Survey: Building Characteristics; March 1981, DOE/EIA-0246, GPO Stock No. 061-003-00171-8, \$6.50.

Consumption and Expenditures

Nonresidential Buildings Energy Consumption Survey: Commercial Buildings Consumption and Expenditures 1986; May 1989, DOE/EIA-0318(86), GPO Stock No. 061-003-00613-2, \$19.00.

Nonresidential Buildings Energy Consumption Survey: Commercial Buildings, Consumption and Expenditures 1983; September 1986, DOE/EIA-0318(83), GPO Stock No. 061-003-00496-2, \$13.00.

Nonresidential Buildings Energy Consumption Survey: 1979 Consumption and Expenditures, Part 1: Natural Gas and Electricity; March 1983, DOE/EIA-0318/1, GPO Stock No. 061-003-00298-6, \$9.50.

Nonresidential Buildings Energy Consumption Survey: 1979 Consumption and Expenditures, Part 2: Steam, Coal, Fuel Oil, LPG, and Total Fuels; December 1983, DOE/EIA-0318(79)/2, GPO Stock No. 061003-00366-4, \$6.00.

Residential Transportation Sector

Note: The survey name was dropped from the beginning of the report title starting with the 1988 data report, and the report title changed to "Household Vehicles Energy Consumption 1988."

Household Vehicles Energy Consumption 1988; February 1990, DOE/EIA-0464(88), GPO Stock No. 061-003-00652-3, \$11.00.

Residential Transportation Energy Consumption Survey: Consumption Patterns of Household Vehicles 1985; April 1987, DOE/EIA-0464(85), GPO Stock No. 061-003-00521-7, \$8.50.

Residential Transportation Energy Consumption Survey: Consumption Patterns of Household Vehi-

cles, 1983; January 1985, DOE/EIA-0464(83), GPO Stock No. 061-003-00420-2, \$4.50.

Residential Energy Consumption Survey: Consumption Patterns of Household Vehicles, Supplement: January 1981 to September 1981; February 1983, DOE/EIA-0328, GPO Stock No. 061-003-00297-8, \$4.75.

Residential Energy Consumption Survey: Consumption Patterns of Household Vehicles, June 1979 to December 1980; April 1982, DOE/EIA-0319 (no GPO Stock No.).

Residential Sector

Housing Characteristics

Note: The survey name was dropped from the beginning of the report title starting with the 1987 data reports.

Housing Characteristics 1987; May 1989, DOE/EIA-0314(87), GPO Stock No. 061-003-00619-1, \$13.00.

Residential Energy Consumption Survey: Housing Characteristics 1984; October 1986, DOE/EIA-0314(84), GPO Stock No. 061-003-00499-7, \$12.00.

Residential Energy Consumption Survey: Housing Characteristics, 1982; August 1984, DOE/EIA-0314(82), GPO Stock No. 061-003-00393-1, \$7.00.

Residential Energy Consumption Survey Housing Characteristics, 1981; August 1983, DOE/EIA-0314(81), GPO Stock No. 061-003-00330-3, \$6.50.

Residential Energy Consumption Survey: Housing Characteristics, 1980; June 1982, DOE/EIA-0314, GPO Stock No. 061-003-00256-1, \$11.00.

Residential Energy Consumption Survey: Characteristics of the Housing Stock and Households, 1978; February 1980, DOE/EIA-0207/2, GPO Stock No. 061-003-00093-2, \$4.25.

Residential Energy Consumption Survey: Conservation; February 1980, DOE/EIA-0207/3, GPO Stock No. 061003-00087-8, \$6.00.

Preliminary Conservation Tables from the National Interim Energy Consumption Survey; August 1979, DOE/EIA-0193/P (no GPO Stock No.).

Characteristics of the Housing Stock and Households: Preliminary Findings from the National Interim Energy Consumption Survey; October 1979, DOE/EIA-0199/P (no GPO Stock No. available).

Consumption and Expenditures

Note: The survey name was dropped from the beginning of the report title starting with the 1987 data reports. The titles were changed to *Household Energy Consumption and Expenditures 1987, Part 1: National and Part 2: Regional.*

Household Energy Consumption and Expenditures 1987, Part 1: National Data; October 1989, DOE/EIA-0321/1(87), GPO Stock No. 061-003-00635-3, \$15.00. Note: Energy end-use data are included in this report.

Household Energy Consumption and Expenditures 1987, Part 2: Regional Data; DOE/EIA-0321/2(87) (no GPO Stock No available), \$16.00.

Residential Energy Consumption Survey: Consumption and Expenditures, April 1984 Through March 1985, Part 1: National Data; March 1987, DOE/EIA-0321/1(84), GPO Stock No. 061-003-00519-5, \$9.50.

Residential Energy Consumption Survey: Consumption and Expenditures, April 1984 Through March 1985, Part 2: Regional Data; May 1987, DOE/EIA-0321/2(84), GPO Stock No. 061-003-00528-4, \$17.00. Note: Energy end-use data are included in this report.

Residential Energy Consumption Survey: Consumption and Expenditures, April 1982 Through March 1983, Part 1: National Data; November 1984, DOE/EIA-0321/1(82), GPO Stock No. 061-003-00411-3, \$7.00.

Residential Energy Consumption Survey: Consumption and Expenditures, April 1982 Through March 1983, Part 2: Regional Data; December 1984, DOE/EIA-0321/2(82), GPO Stock No. 061-003-00414-8, \$9.50.

Residential Energy Consumption Survey: Consumption and Expenditures, April 1981 Through March 1982, Part 1: National Data; September 1983, DOE/EIA-0321/1(81), GPO Stock No. 061-003-00340-1, \$6.00.

Residential Energy Consumption Survey: Consumption and Expenditures, April 1981 Through March 1982, Part 2: Regional Data; October 1983, DOE/EIA-0321/2(81), GPO Stock No. 061-003-00357-5, \$8.00.

Residential Energy Consumption Survey: Consumption and Expenditures, April 1980 Through March 1981, Part 1: National Data; September 1982, DOE/EIA-0321/1(80), GPO Stock No. 061-003-00278-1, \$7.50.

Residential Energy Consumption Survey: Consumption and Expenditures, April 1980 Through March 1981, Part 2: Regional Data; June 1983, DOE/EIA-0321/2(80), GPO Stock No. 061-003-00319-2, \$7.00.

Residential Energy Consumption Survey: 1979-1980 Consumption and Expenditures, Part 1: National Data (Including Conservation); April 1981, DOE/EIA-0262/1, GPO Stock No. 061-00300191-2, \$6.50.

Residential Energy Consumption Survey: 1979-1980 Consumption and Expenditures, Part II: Regional Data; May 1981, DOE/EIA-0262/2, GPO Stock No. 061-003-00189-1, \$8.50.

Residential Energy Consumption Survey: Consumption and Expenditures, April 1978 Through March 1979; July 1980, DOE/EIA-0207/5, GPO Stock No. 061-003-00131-9, \$7.50.

Single-Family Households: Fuel Oil Inventories and Expenditures: National Interim Energy Consumption Survey; December 1979, DOE/EIA-0207/1, GPO Stock No. 061-003-00075-4, \$3.50.

Other Publications on the Residential Sector

"End-Use Consumption of Residential Energy" (Article), pp. vii-xiv, Monthly Energy Review, July 1987, DOE/EIA-0035(87/07).

Residential Energy Consumption Survey: Trends in Consumption and Expenditures 1978-1984 June 1987, DOE/EIA-0482, GPO Stock No. 061-003-00535-7, \$12.00.

Residential Conservation Measures; July 1986, SR/EEUD/86/01 (no GPO Stock No.).

An Economic Evaluation of Energy Conservation and Renewable Energy Tax Credits; October 1985, Service Report (no GPO Stock No.).

Residential Energy Consumption and Expenditures by End Use for 1978, 1980, and 1981; December 1984, DOE/EIA-0458, GPO Stock No. 061-003-00415-6, \$4.50.

Weatherization Program Evaluation, SR-EEUD-84-1; August 1984 (available from the Office of the Assistant Secretary for Conservation and Renewable Energy, Department of Energy).

Residential Energy Consumption Survey: Regression Analysis of Energy Consumption by End Use; October 1983, DOE/EIA-0431, GPO Stock No. 061-00300347-8, \$5.00.

National Interim Energy Consumption Survey: Exploring the Variability In Energy Consumption; July 1981, DOE/EIA-0272, GPO Stock No. 061-003-00205-6, \$5.00.

National Interim Energy Consumption Survey: Exploring the Variability in Energy Consumption--A Supplement; October 1981, DOE/EIA-0272/S, GPO Stock No. 061-003-00217-0, \$4.50.

Energy Use by U.S. Households; November 1980, DOE/EIA-0248 (brochure, no GPO Stock No.).

Cross-Sector

Energy Consumption by End-Use Sector: A Comparison of Measures by Consumption and Supply Surveys; April 6, 1990, DOE/EIA-0533 (no GPO Stock No. available), \$2.50.

Natural Gas: Use and Expenditures; April 1983, DOE/EIA-0382, GPO Stock No. 061-003-00307-9, \$5.50.

Public Use Tapes

Note: All tapes are available through the NTIS.

Residential and Residential Transportation Sectors

Residential Energy Consumption Survey: 1987 and Residential Transportation Energy Consumption Survey, 1988, Order No. PB90-501461, \$220.

Residential Energy Consumption Survey: 1984 and Residential Transportation Energy Consumption Survey, 1985; Order No. PB87-186540, \$220.

Residential Energy Consumption Survey: 1982 and Residential Transportation Energy Consumption Survey, 1983; Order No. PB85-221760, \$220.

Residential Energy Consumption Survey: Consumption and Expenditures, 1980-1981; Monthly Billing Data; Order No. PB84-166230, \$220.

Residential Energy Consumption Survey: Housing Characteristics, 1981; Consumption and Expenditures, 1981-1982; Monthly Billing Data; Order No. PB84-120476, \$220.

Residential Energy Consumption Survey: Housing Characteristics, Annualized Consumption and Expenditures, 1980-1981; Order No. PB83-199554, \$220.

Residential Energy Consumption Survey: Household Transportation Panel Monthly Gas Purchases and Vehicle and Household Characteristics, 6/79-9/81; Order No. PB84-162452, \$220.

Residential Energy Consumption Survey: Household Screener Survey, 1979-1980; Order No. PB82-114877, \$220.

Residential Energy Consumption Survey: Household Monthly Energy Consumption and Expenditures, 1978-1979; Order No. PB82-114901, \$220.

National Interim Energy Consumption Survey (Residential), 1978; Order No. PB81-108714, \$220.

Commercial Sector

Nonresidential Buildings Energy Consumption Survey: 1986 Data; Order No. PB90-500034, \$220.

Nonresidential Buildings Energy Consumption Survey: 1979 and 1983 Data; Order No. PB88-245162, \$220.

Public Use Diskettes

Note: Diskettes are available through the NTIS and GPO.

Residential Energy Consumption Survey 1987 Data, NTIS - ASCII format: Order No. PB-91-505115, \$130, and dBASE format: Order No. PB-91-505107, \$130.

GPO - ASCII/dBASE format, order by title, \$45 for each set.

Nonresidential Buildings Energy Consumption Survey 1986 Data, ASCII format: Order No. PB91-506808, \$130.

Residential Transportation Energy Consumption Survey 1988 Data, NTIS - ASCII format: Order No. PB91-507269, dBASE format: Order No. PB91-507277, \$50 each.

GPO - ASCII/dBASE format, order by title, \$15 for each set.

Planned Publications

Manufacturing Energy Consumption Survey: Changes in Energy Efficiency Through 1988; planned for January 1992.

Manufacturing Energy Consumption Survey: Changes in Energy Consumption 1985 - 1988; planned for early 1992.

Commercial Buildings Consumption and Expenditures 1989; planned for early 1992.

Housing Characteristics 1990; planned for March 1992.

Household Energy Consumption and Expenditures 1990, Part 1: National Data; planned for September 1992.

Household Energy Consumption and Expenditures 1990, Part 2: Regional Data; planned for December 1992.

Household Vehicles Energy Consumption 1991; planned for December 1992.

Note: the Energy Information Administration also publishes the *State Energy Data Report Consumption Estimates* annually, DOE/EIA-0214.

Glossary

Anthracite: A hard, black, lustrous coal containing a high percentage of fixed carbon and a low percentage of volatile matter. It is often referred to as hard coal.

Barrel: A volumetric unit of measure equivalent to 42 U.S. gallons.

Biomass: Organic (animal waste), nonfossil plant material constituting an exploitable energy source.

Bituminous Coal: A soft coal (the most common solid fossil fuel), which is high in carbonaceous matter, with a volatility greater than anthracite.

Blast Furnace: A shaft furnace in which solid fuel is burned with an air blast to smelt ore in a continuous operation.

Blast Furnace Gas: The waste combustible gas generated in a blast furnace when iron ore is being reduced with coke to metallic iron. It is commonly used as a fuel within the steel works.

Breeze: The residue from the fine screenings of crushed coke.

British Thermal Unit (Btu): The amount of energy required to raise the temperature of one pound of water one degree Fahrenheit.

Butane (C₄H₁₀): A normally gaseous, paraffinic hydrocarbon extracted from natural gas or refinery gas streams. It includes isobutane (a branch-chain configuration) and isobutane (a straight-chain configuration). It is used primarily for blending into high-octane gasoline, for residential and commercial heating, and for industrial uses, especially the manufacture of chemicals and rubber.

Butylene (C₄H₈): A normally gaseous, olefinic hydrocarbon recovered from the refinery processes, and converted to alkylate, a high-octane gasoline blending component.

Byproduct: A secondary or additional product resulting from the feedstock use of energy or the processing of nonenergy materials. For example, the more common byproducts of coke ovens are

coal gas, tar, and a mixture of benzene, toluene, and xylenes (BTX).

Census Region: A geographic area defined by the Bureau of the Census, consisting of various States selected according to population size and physical location. The States are grouped into four regions:

1. Northeast: Connecticut, Maine, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, and Vermont.
2. South: Alabama, Arkansas, Delaware, District of Columbia, Florida, Georgia, Kentucky, Louisiana, Maryland, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, Virginia, and West Virginia.
3. Midwest: Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Ohio, South Dakota, and Wisconsin.
4. West: Alaska, Arizona, California, Colorado, Hawaii, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, and Wyoming.

Coal Coke: The strong, porous residue, consisting of carbon and mineral ash, which is formed when the volatile constituents of bituminous coal are driven off by heat in the absence of or with a limited supply of air. Coal coke is used primarily in blast furnaces.

Cogeneration: The production of electrical energy and another form of useful energy (such as heat or steam) through the sequential use of energy.

Coke Oven Gas: The mixture of permanent gases produced by the carbonization of coal in a coke oven at temperatures in excess of 1,000 degrees Celsius.

Consumption: The use of energy as a source of heat or power, or as an input to the manufacturing process.

Conversion Factor: A number which translates units of one system into corresponding values of

another system. Conversion factors are used to translate physical units of measure for various energy sources into their Btu equivalents.

Crude Oil: A mixture of hydrocarbons that exists in a liquid state in natural underground reservoirs and remains liquid at atmospheric pressure after passing through surface separating facilities. Crude oil is reported as liquid equivalents at the surface (excluding basic sediment and water), measured in terms of stock tank barrels of 42 U.S. gallons at atmospheric pressure, and corrected to 60 degrees Fahrenheit.

Distillate Fuel Oil: A general classification for light fuel oils distilled during the refining process. The classification includes products known as Nos. 1, 2, and 4 fuel oils; and Nos. 1, 2, and 4 diesel fuels. Distillate fuel oil is used primarily for space heating, on-and-off highway engine fuel, and electric power generation.

Energy: The capacity for doing work as measured in the capability of doing work (potential energy) or the conversion of this capability to motion (kinetic energy).

Energy Source: A substance such as natural gas, coal, or electricity that supplies heat or power.

Establishment: As defined by the 1987 *Standard Industrial Classification Manual*, "...an economic unit, generally at a single physical location, where business is conducted or where services or industrial operations are performed." (See *Manufacturing Establishment*.)

Ethane (C₂H₆): A colorless, odorless, gaseous hydrocarbon extracted from natural gas or refinery gas streams. Ethane is used primarily as a petrochemical feedstock for the production of chemicals and plastic materials.

Ethylene (C₂H₄): A colorless, flammable, gaseous olefinic hydrocarbon recovered from natural gas and petroleum. Ethylene is used primarily as a petrochemical feedstock for numerous chemical applications and the production of consumer goods.

Expenditures: Funds spent for energy purchased and paid for, or delivered to a manufacturer during a calendar year. For the purposes of the MECS, the expenditure dollar includes State and local taxes and delivery charges.

Fossil Fuel: Any naturally occurring organic fuel, such as coal, crude oil, and natural gas.

Fuel: Any substance that can be burned to produce heat.

Fuel Use (of Energy): Use of energy in the production of heat, steam, power, or the generation of electricity.

Generation: The process of producing steam or electrical energy by transforming other forms of energy.

Geothermal Energy: Hot water or steam, extracted from reservoirs in the earth's crust, which is generally supplied to steam turbines that drive generators to produce electricity.

Hydroelectric Power: Electricity generated by a turbine driven by falling water.

Hydrogen (H₂): A colorless, odorless, highly flammable gaseous element; the lightest of all gases and the most abundant element in the universe.

Industrial Sector: A subdivision of U.S. economic activity defined by the Energy Information Administration to include manufacturing, construction, mining, agriculture, fishing, and forestry establishments.

Kilowatthour (kWh): A unit of work or energy, measured as 1,000 watts (1 kilowatt) of power expended for 1 hour. Once generated, one kWh is equivalent to 3,412 Btu.

Liquefied Petroleum Gases (LPG): Ethane, ethylene, propane, propylene, normal butane, butylene, ethane-propanemixtures, propane-butanemixtures, and isobutane produced at refineries or natural gas processing plants, including plants that fractionate raw natural gas plant liquids.

Lease Condensate: A natural gas liquid recovered from gas well gas (associated and nonassociated) in lease separators or field facilities. Lease condensate consists primarily of pentanes and heavier hydrocarbons. Volumes are reported in terms of barrels of 42 U.S. gallons, at atmospheric pressure, and corrected to 60 degrees Fahrenheit.

Lease Separator: A facility located at the surface for the purposes of (1) separating casinghead gas from produced crude oil and water at the tempera-

ture and pressure conditions of the separator; and (2) separating gas from that portion of associated gas and nonassociated gas which liquefies at temperature and pressure conditions of the separator.

Lignite: A brownish-black coal of low rank with a high percentage of inherent moisture and volatile matter content. It is also referred to as brown coal.

Manufacturing Establishment: An economic unit at a single physical location where mechanical or chemical transformation of materials or substances into new products are performed. These operations are generally conducted in facilities described as plants, factories, or mills, and characteristically use power-driven machines and materials-handling equipment. In addition, the assembly of components of manufactured products is considered manufacturing, as in the blending of materials such as lubricating oils, plastics, resins, or liquors. (See *Establishment*.)

Manufacturing Sector (Division): One of 10 fields of economic activity defined by the *Standard Industrial Classification Manual*. The manufacturing sector includes all establishments engaged in the mechanical or chemical transformation of materials or substances into new products. Other divisions of the U.S. economy are agriculture, forestry, fishing, hunting, and trapping; mining; construction; transportation, communications, electric, gas, and sanitary services; wholesale trade; retail trade; finance, insurance, and real estate; personal, business, professional, repair, recreation, and other services; and public administration. The establishments in the manufacturing sector constitute the universe for the MECS.

Motor Gasoline: A complex mixture of relatively volatile hydrocarbons, with or without small quantities of additives, obtained by blending appropriate refinery streams to form a fuel suitable for use in spark-ignition engines. Motor gasoline includes both leaded and unleaded grades of finished motor gasoline, blending components, and gasohol.

Natural Gas: A mixture of hydrocarbon compounds and small quantities of various nonhydrocarbons existing in the gaseous phase or in solution with oil in natural underground reservoirs at reservoir conditions. Natural gas may be subclassified as:

1. **Associated Gas:** Free natural gas, commonly known as gas-cap gas, which overlies and is in contact with crude oil in the reservoir.
2. **Dissolved Gas:** Natural gas which is in solution with crude oil in the reservoir at reservoir conditions.
3. **Nonassociated Gas:** Free natural gas not in contact with crude oil in the reservoir.

All natural gas volumes are reported in cubic feet at a pressure base of 14.73 psia, at 60 degrees Fahrenheit.

Nonfuel Use (of Energy): Use of energy as a feedstock or raw material input.

Petroleum Coke: A solid residue, high in carbon content and low in hydrogen, which is the final product of thermal decomposition in the condensation process in cracking crude oil. Petroleum coke can yield almost pure carbon or artificial graphite suitable for the production of carbon or graphite electrodes, structural graphite, motor brushes, dry cells, and similar products.

Petrochemical Feedstock: Chemical feedstocks derived from petroleum, and used principally for the manufacture of chemicals, synthetic rubber, and a variety of plastics.

Plant: Commonly used as a synonym for an establishment. However, the term can also be used to refer to a particular process within an establishment.

Propane (C₃H₈): A colorless, gaseous hydrocarbon extracted from natural gas or refinery gas streams. It is used primarily for residential and commercial heating and cooling, and also as a fuel for transportation. Industrial applications include use as a petrochemical feedstock.

Propylene (C₃H₆): A gaseous hydrocarbon recovered from refinery processes. Propylene is used primarily as a petrochemical feedstock.

Pulping Liquor (Black Liquor): The alkaline spent liquor removed from the digesters in the process of chemically pulping wood. After evaporation, the liquor is burned as a fuel in a recovery furnace that permits the recovery of certain basic chemicals.

Quadrillion Btu: Equivalent to 10¹⁵ Btu.

Refinery: A plant, device, or process which heats crude oil so that it separates into chemical components, which are then distilled off as more usable substances.

Relative Standard Error (RSE): A percentage measure of the precision of a survey statistic. The RSE is defined as the standard error of a survey estimate divided by the survey estimate and multiplied by 100. The standard error is the square root of the variance.

Residual Fuel Oil: The general classification for the heavier oils that remain after the distillate fuel oils and lighter hydrocarbons are distilled away in refinery operations. The classification includes No. 5 (light and heavy), No. 6 (including heavy-grade, so called Bunker C oil), and Navy Special fuel oil.

Roundwood: Wood cut specifically for use as a fuel.

Short Ton: A unit of weight equal to 2,000 pounds.

Solar Energy: The radiant energy of the sun, which can be converted into other forms of energy, such as heat or electricity.

Standard Industrial Classification (SIC): A classification scheme developed by the Office of Management and Budget, which categorizes establishments into groups with similar economic activities.

Still Gas (Refinery Gas): Any form or mixture of gas produced in refineries by distillation, cracking, reforming, and other processes, the principal constituents of which are methane, hydrogen, ethane, ethylene, propane, propylene, butanes, butylene, etc. Still gas is used as a petrochemical feedstock and as a fuel in refineries.

Storage Capacity: For the purposes of the MECS, storage capacity includes any volumetric capacity (including tank tops and tank bottoms) that is on the establishment site even it is dedicated or leased for the storage of an energy source by other establishments.

Subbituminous Coal: A dull, black coal of intermediate rank between lignite and bituminous coal. Subbituminous coal, like bituminous coal, is used as a fuel.

Turbine: A machine for generating rotary mechanical power from an energy stream (such as water, steam, or hot gas). Turbines convert kinetic energy to mechanical energy through the principles of impulse and reaction, or a mixture of the two.

Waste Materials: Otherwise discarded combustible materials which, when burned, produce energy for such purposes as space heating and electric power generation. The size of the waste may be reduced by shredders, grinders, or hammermills. Noncombustible materials, if any, may be removed. The waste may be dried and then burned, either alone or in combination with fossil fuels.

Waste Oils and Tar: Petroleum-based materials that are worthless for any purpose other than fuel use.

Wind Energy: Energy present in wind motion that can be converted to mechanical energy for driving pumps, mills, and electric power generators. Wind pushes against sails, vanes, or blades radiating from a central rotating shaft.

Wood Waste: Wood byproducts used as a fuel. Included are limb wood, wood chips, bark, sawdust, forest residues, charcoal, and pulp waste.